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POSTURE HEARINGS

(NSF, NBS and FEMA)

HEARING
BEFORE THE
COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
NINETY-SIXTH CONGRESS
SECOND SESSION

JANUARY 30, 1980

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POSTURE HEARINGS (NSF, NBS and FEMA)

WEDNESDAY, JANUARY 30, 1980

House of Representatives,
Committee on Science and Technology,
Washington, D.C.

The committee met, pursuant to notice, at 10:07 a.m., in room 2318 Rayburn House Office Building, Hon. Don Fuqua, chairman of the committee, and Hon. George E. Brown, Jr., acting chairman of the committee, presiding.

The Chairman. The committee will be in order.

This morning we continue the committee's posture hearings on science and technology which began yesterday.

Our witnesses today are the heads of three agencies which play a central role in the Nation's basic and applied research enterprise.

The National Science Foundation is unique among Federal agencies in its responsibility for cultivating a strong national basic research capability—across all sciences—and for its special role in science education.

In addition, some of its research, both basic and applied, is relevant to the missions of other agencies. For example, with regard to the agencies represented today, all three have roles in the national earthquake program.

The NSF is represented today by its Director, Dr. Richard Atkinson, and the Chairman of the National Science Board, Dr. Norman Hackerman.

Also, here to discuss the role of our Nation's oldest national laboratory, the National Bureau of Standards, is the Bureau's Director, Dr. Ernest Ambler. The economic health of the Nation depends to a large degree on the use of science and technology to meet pressing national problems in measurements and standard setting, and in many related areas. Our objective is to encourage a strong NBS that continues to contribute to the creation and transfer of new knowledge important to our economic growth.

The Federal Emergency Management Agency is represented by its first Director, Mr. John Macy. Mr. Macy has the challenging task of integrating the research and other program elements of five previously separate agencies and a number of other disaster-related activities. The committee is particularly interested in the progress of and the prospects for the fire and earthquake programs of FEMA.

We have asked you to come before the committee today to explore with us the broader framework in which your individual agency budgets must be viewed. The long-term health of American science and technology during the balance of this decade, and beyond, must be of concern to all of us, and we welcome you here today to our posture hearing.

The Chairman of the Subcommittee on Science Research and Technology, the Honorable George Brown, is recognized for a statement that he wishes to make.

Mr. BROWN. Mr. Chairman, I will only second what you have already said so well, and point out that these hearings are part of a broader concern on the part of the committee for developing a coherent strategy for science and technology that runs across the whole gamut of the government and, hopefully, achieves reasonable goals for the Nation as a whole.

I will call attention to the fact that later in the week, on Friday, we are inviting members of the committee who wish to do so to visit the National Bureau of Standards and get a firsthand view of the laboratory which you referred to as one of the oldest, if not the oldest, in the Nation. I hope that as many members of the committee as possible will take advantage of this scheduled opportunity.

I ask unanimous consent to revise and extend my remarks.

The CHAIRMAN. If you don't object, I won't.

[The opening statement of Hon. George E. Brown, Jr., follows:]

OPENING STATEMENT OF HON. GEORGE E. BROWN, JR.

Thank you Mr. Chairman. I would just like to say that I appreciate this unusual opportunity to take a broad look at how Federal R&D agencies relate to each other, and to examine how time and external forces may affect their several roles.

It is a good way to prepare for the authorization hearings that will begin next week for these agencies.

Authorization of both the Bureau of Standards and the Federal Emergency Management Agency is a new undertaking for us, and we have some learning to do. The National Science Foundation is more familiar, but I am sure we will benefit from thinking about its place in the larger scheme of Federal R&D, and about the changing climate in which all R&D agencies are likely to move through the coming years.

I anticipate that Mr. Macy's testimony, both today and later next month, will give us his view, literally from the ground floor up, of the future of this new Federal agency. We probably should plan to stomp around on that floor a bit to check the strength of its foundation.

I will also take this opportunity to invite all members of the committee to join us this coming Friday when we will inspect the Bureau of Standards' research facilities at Gaithersburg, Md. Cars will leave at 8:30 a.m. and we expect to be back at noon.

Our budget authorization hearing for the National Science Foundation will reflect somewhat our concern about trends and external factors. We are reserving 2 special days for reviewing two problem areas in which long-term trends are important: science education and the social and behavioral sciences. Both of these areas have important implications for the work of other Federal agencies. We also want to take a careful look at the proposed new ocean drilling program, giving particular attention to the part that will, ought, or might, be played by industry, by other government agencies, and perhaps by other countries.

Mr. Chairman, I am glad you have arranged this opportunity to emphasize the broad range and long range view, and I expect we will all profit from it.

The CHAIRMAN. Mr. Hollenbeck has a statement, and we would ask that it be included in the record at this point.

[The statement of Hon. Harold C. Hollenbeck is as follows:]

STATEMENT OF HON. HAROLD C. HOLLENBECK

Mr. Chairman, since we are examining the general balance of priorities in Federal research and development money I will keep my remarks very brief, but make two points specifically with reference to the National Science Foundation.

First, I believe that the National Science Foundation, under its current leadership, does not devote sufficient importance to its science education programs. In this connection, I would like to include in the record an article which I read yesterday by Fred Hechinger in the New York Times' "Science Times" section. That article presents the views of Dr. Gerrold Zacharias, who was a pioneer in the development of new physics curriculum which revolutionized the teaching of the natural sciences during the 1950's and early 1960's. Dr. Zacharias is alarmed by the decline in high school instruction of physics, science and mathematics, which is occurring nationwide. Yet in this day and age, in his words, "individuals and nations have no other options than being part of a scientific society." The fault he says is with university scientists and the National Science Foundation. Professional scientists have fought only for money for themselves in recent years and are back reproducing graduate students in their own image. There is no thread of leadership today. The Federal Government is not a source of educational reform, it is just a check-writing operation. The National Science Foundation wants the big amounts for research and peanuts for education.

While there is an enormous amount of very valid scientific research to be done, and I would hope that we would not reduce the amount of basic research; nevertheless, I believe that the Science Foundation must exert a much greater commitment to science education—even if that requires fighting hard for a higher overall budget. Within the context of reduced or static budgets, I would argue still for a greater commitment to science education.

Second, applied science is an area which is too big perhaps to be handled within the context of current NSF budgets, for you are really talking about the remaking of the American economy. That may require the institution of an organization like the proposed National Technology Foundation to handle broad classes of applied research, but preserving very close coordinated and perhaps even managerial links with the National Science Foundation. But right now applied science is slighted in dollars; the balance between applied and basic research in the NSF budget is not there.

Once again I emphasize that I do not want to cut basic research in order to bolster applied research. If, however, the Science Foundation is to preserve its role here, then they must give greater evidence of their genuine commitment to developing a truly effective applied science and industrial innovation program.

[From the New York Times]

ABOUT EDUCATION

SOLVING THE CASE OF THE CLASSROOMS' MISSING SCIENTISTS

(By Fred M. Hechinger)

The scientist who revolutionized the reform of high school science teaching almost 25 years ago charges that the reforms have been killed by the very people who have most to lose from such a course—the scientists themselves.

Dr. Jerrold R. Zacharias, one of the nation's leading physicists, in 1956 left the lofty realm of university scholarship to rewrite the high school physics curriculum. He scrapped the traditional "cookbook" approach in which students memorized theories and then proved them in prescribed laboratory procedures. In its place he put scientific discovery through "hands-on" experimentation and observation. Improvised ripple tanks made of store window frames, which allowed students to observe the actions of light, waves and sound in and through water, became one of the symbols of the Zacharias school of science.

But more important than the specific changes in physics teaching was the effect of Dr. Zacharias's descent to the public school classroom on many other university scientists, who suddenly discovered that it was more productive to show schools how to do it than to blame them for not doing it. The movement spread to biology, chemistry and mathematics. The Federal Government, largely through the National Science Foundation, provided the funds to develop new teaching materials and textbooks (which eventually were taken over by commercial publishers) and to train and retrain teachers. The first Soviet sputnik in 1957—one year after Dr. Zacharias' reforms had been launched—sent the pedagogical reforms into orbit.

Now, Prof. Zacharias said recently in an interview, the reform movement is little more than a memory. Gerald Piel, the publisher of Scientific American, in an article on "the sorry state of school science" in the current issue of The National

Elementary Principal, confirms that the pioneer physics curriculum devised by Dr. Zacharias is used in only four percent of the nation's school districts today—down from 14 percent a few years ago. More than half of all high schools require only one year of instruction in science and mathematics, and many offer no physics at all.

Dr. Zacharias believes that this does nothing for the improvement of school science teaching at the very time when, he warns, "Individuals and nations have no other options than being part of a scientific society." A recent panel on school science under the auspices of the National Research Council charged that the prevailing preoccupation with the psychic, the mystic and the occult makes it apparent that an alarming number of adults cannot tell sense from nonsense.

The N.S.F., Dr. Zacharias believes, moved away from school science in part because "it wasn't willing to brazen out one major failure—the new math—and one minor failure" of the reforms. The minor failure, he says, was the scientific establishment's inability to stand up to those who attacked the new biological study maetrials, particularly in the elementary schools, for their evolutionary rather than biblical account of creation.

Lack of sufficient money, however, is a crucial factor. During the 1950's and 1960's, the N.S.F. spent $1 billion on the reform of high school science. Without money, says Dr. Zacharias, there is no way to keep an entrepreneurship going.

"In my days," he adds, meaning the period from 1956 to 1966, "there was enough money so that we could recruit busy people and assure them that, if they got into this, something would come of it."

Money is not the only issue. "There's no shred of leadership today," Prof. Zacharias says. "The Federal Government is no source of educational reform; it's just a check-writing operation, and the N.S.F. wants the big amounts for research and peanuts for education."

Dr. Zacharias hopes to get about 50 professional scientists together to talk about the issues for a week. "They'll find the major problem is teacher education," he says. The way to get the reform movement started again, he believes, is to begin with the subject of energy because "it's on people's minds and it's in enough trouble." It is, he admits, an effort to build a political base for science first and then attempt to get it back into the schools.

"I'm still crazy enough to try it," he says. He is still determined to solve "the case of the missing scientists" in the elementary and high schools.

[Budget histories documentation is as follows:]

READEX FICHE

BUDGET HISTORIES
(in millions)

National Science Foundation

	FY 80 Request	FY 80 Appr.	FY 81 Request	Increase	% Increase
Total:	1,006	996	1,148	152	15%

NSF Budget Highlights
for Posture Hearing 1/30/80

President's budget request for NSF ------- $1,148,000,000
------- 15.5% increase over FY 80 program
------- 16.1% increase for basic research
------- 25.4% increase for applied research
------- 9.6% increase for science educatio

Offset by 10% inflation rate (OMB estimate)

Major features or thrusts:

- Large increases in Industry/University Coop. Research and for Small Business innovative research
- Upgrading of university research labs and equipment
- Beginning of a 10-year ocean floor drilling program in cooperation with industry ("Ocean Margin Drilling")
  1st year cost: $10 million NSF + $10 million industry
- Computer science and engineering, 28% increase
- Cooperative Automobile Research - Government and industry - Government share to be paid out of oil windfall profits tax income.
- International programs have 2 major components:
  US/USSR coop. research program, $3.2 million
  US/China coop. research program, $2.0 million

National Bureau of Standards

	FY 80 Request	FY 80 Appr.	FY 81 Request	Increase	% Increase
Total:	96	95	107	12	12%

1981 Request for Appropriation	--------	$107.9 million
1981 Other Agency & Reimbursable Programs	--------	$ 78.7 million
1981 estimated Operating Program	--------	$182.7 million

(Program Changes):	Basic Research	--------	+ $5.0 million
	Technical Competence	--------	+ 2.0 million
	VLSI	--------	+ 3.3 million
	Computing Services	--------	+ 1.0 million
	Facilities Modifications	--------	+ 0.4 million
	Field Methods Production	--------	- 0.6 million

FEDERAL EMERGENCY MANAGEMENT AGENCY
COMPARISON OF FY 1980 AND FY 1981
($ in thousands)

	FY 1980	FY 1981
Plans and Preparedness	$ 86,420	$ 99,060
Insurance Administration	77,234	674,369 [3]
Fire Administration	20,489	21,889
Training and Education	9,410	10,736
Mitigation and Research	5,887 [1]	9,927 [4]
Disaster Response	194,398 [2]	382,831 [5]
Operations Support	35,260	40,831
Executive Direction	12,632	12,948
AGENCY TOTAL	$441,930	$1,252,591

The above does not include a proposed supplemental of $8.9 million for Radiological Response, a supplemental of $314 million for Disaster Response, and a supplemental of $3.7 million for the FY 1980 pay raise.

1 Does not include fire research $3,895 and Earthquake loss & preparedness studies $ 475

2 $[illegible] in President's Disaster Relief Fund

3 $[illegible] is for repayment of Borrowing Authority. Comparable figure to FY 80 is 271,369

4 Does not include $4,259 for fire research or $ 475 for Earthquake loss and preparedness studies

5 $375,570 is the President's Disaster Relief Fund

1/29/80

The **Chairman**. I think our format this morning, gentlemen, will be to hear from all of the witnesses and then have questions because many of the questions probably will relate to the work that you're involved in, and the interrelationships. I think that may help utilize our time better.

We will begin with Dr. Richard C. Atkinson, the Director of the National Science Foundation.

[A biographical sketch of Dr. Atkinson follows:]

NATIONAL SCIENCE FOUNDATION
OFFICE OF THE DIRECTOR
WASHINGTON, D.C. 20550

RICHARD C. ATKINSON
DIRECTOR

Dr. Richard C. Atkinson was sworn in before President Carter on June 1, 1977, as Director of the National Science Foundation. He was nominated for the position by President Carter on April 21, 1977, and unanimously confirmed by the Senate on May 3, 1977. Dr. Atkinson had been Acting Director of the Foundation since August 12, 1976. He is on leave of absence from Stanford University where he had been on the faculty since 1956.

Dr. Atkinson is an experimental psychologist and applied mathematician whose research has been concerned primarily with problems of memory and cognition. He was one of the first to transform intuitive ideas about the nature of memory into an explicit theory that could be formulated in mathematical terms. This theory has been the basis for much of the current research on human memory. The theory also has played an important role in specifying correlates between brain structures and psychological phenomena, in explaining the effects of drugs on memory, and in providing techniques for optimizing the learning process.

Dr. Atkinson's research on memory has led him to be concerned with problems of classroom learning. He was among the first to develop a computer-controlled system for instruction, whose basic features have had wide influence on the computer field and have been used in the design of commercial computer-assisted instruction programs. An important application of the computer system developed by Dr. Atkinson has been for teaching reading to elementary school children.

Dr. Atkinson was born March 19, 1929, in Oak Park, Illinois. He earned a bachelor of science degree at the University of Chicago in 1948, and a doctor of philosophy degree at Indiana University in 1955. He has been elected to membership in the National Academy of Sciences, the Institute of Medicine, the American Academy of Arts and Sciences, and the National Academy of Education. He has been a Fellow of the Center for Advanced Study in the Behavioral Sciences, a Fellow of the Guggenheim Foundation, a recipient of the Distinguished Research Award from the Social Sciences Research Council, and the Distinguished Scientific Contribution Award of the American Psychological Association. He has been awarded honorary degrees by several American universities and holds honorary memberships in a number of foreign societies and academies.

Dr. Atkinson joined the Stanford University faculty in 1956 after military service in the U.S. Army. In addition to being a Professor in the Psychology Department, he holds appointments in the School of Engineering, the School of Education, and the Institute for Mathematical Studies in the Social Sciences.

January 15, 1979

DR. RICHARD C. ATKINSON, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. Atkinson. Mr. Chairman, I will be brief so that your questions may bring out detail.

In my statement, I discuss the issues raised in your letter of invitation: The broad trends in science and technology, the external factors affecting research and development, and NSF's response to these factors. This morning, however, I would like to review the extraordinary events of the seventies in science and suggest a list of key items that point toward further progress in research during the eighties:

The theory of plate tectonics and the role played by NSF's deep sea drilling program in testing the theory;

The development of a research capability, through NSF support, in submicron structures and its impact on micro-electronics, another advance in computer science and the information revolution;

The evolution of recombinant DNA techniques in which the Foundation played an important role;

The development of a comprehensive theory of global atmospheric phenomena and the contribution of large-scale computer models at the National Center for Atmospheric Research to a better understanding of the ozone shield;

The lasers' contribution to revolutionary developments in chemistry that permit probing the structure and reactions of individual molecules;

The recent advances in physics that provide a deeper understanding of some of the atom's building blocks;

The remarkable progress in cloning techniques, particularly in the plant sciences;

The new knowledge in materials science, enabling us to monitor the behavior of individual atoms on the surface of metals; and

The substantial progress in the field of economic theory where research is moving ahead rapidly.

I cite these examples, because I believe they represent a convergence of basic and applied research, a melding of these efforts. A century and a half ago, scientific work was done by an elite group pursuing ideas for their intellectual interest. Technology was pursued by men with practical concerns, and there appeared to be no need for applied research. Fundamental research and practical technology had no meeting ground.

But the situation changed during the past 100 years, in part because it became clear that man's technology must be based on scientific theory. One could conceive of a water-powered mill, for example, but one could not conceive of an electrical motor without understanding the laws of electricity. This realization led gradually to applied research which became a bridge between basic research and the development of new products and processes.

Not too many years ago it was popular to say that a 15-year lag existed between a discovery in a research laboratory and the time that the discovery led to a practical development. In each of the examples I have cited today, we have seen basic research result in immediate and important developments. In turn, those developments have had a profound effect on basic research.

It's clear for example, that plate techtonics theory has affected significantly the research efforts in earthquake prediction and in mineral and petroleum resource exploration. One needs only to look at any newspaper today to read about recombinant DNA activities in industry, particularly the use of DNA techniques to produce human insulin, human hormones, and human interferon. Similarly, research in the materials sciences, is giving us a new understanding of corrosion processes, a problem that costs this society about $70 billion per year, and experiments with cloning techniques are permitting the development of new plant species.

In spite of these examples, it is as important as ever to make the distinction between basic and applied research. Science has its own internal imperatives that drive its activities. It is also affected by the needs of society, and NSF's role is to balance the imperatives of science and the needs of society.

In the past 10 years, the Foundation has experienced an expansion of its role. Ten years ago, the National Science Foundation supported 14 percent of Federal basic research; today, NSF supports 25 percent of the Federal effort in basic research. Similarly, in 1970, NSF provided 26 percent of the Federal basic research funds to U.S. colleges and universities. Today, NSF funds 35 percent of these efforts.

Applied research represents only 8 percent of the Foundation's activities. There is, however, a special role for applied research: NSF is an open window for applied research ideas that do not fit neatly into the niches of specific mission agencies.

Finally, NSF's role in science education was affirmed last year by the Congress in the legislation that established the Department of Education.

Several factors contributed to the development of NSF's budget for fiscal year 1981. There was careful consultation with other agencies on their plans and activities. A data analysis of NSF-funded activities over the past 10 years was conducted on a field-by-field basis. The Five-Year Outlook, which we have as a draft document, assisted in some of the budget decisions. The President's domestic policy review on industrial innovation and the President's interest in basic research also were factors in the budget totals.

The President's budget message selects four areas for special attention in the fiscal year 1981 budget. One is energy; another is defense; the third is basic research, and the fourth is training and education for youth. I think you will find these factors reflected in the resource allocation decisions of the NSF budget.

Now let me mention some special issues in the budget. There are large increases for the physical sciences and mathematics. Computer science, for example, is increased by 28 percent; mathematics by 18 percent; physics and chemistry by about 16 percent.

Why such large increases in these particular areas? The Federal budgets for basic research during the period, 1967 to 1980, show an increase overall, of 8 percent in constant dollars. But on a field-by-field basis, the figures show that Federal support of basic research in the life sciences has been increased by 19 percent in constant dollars. Support of environmental sciences has been increased by 34 percent; the engineering sciences by 22 percent; the social sciences by 7 percent, all in constant dollars.

Why, then, is the average at 8 percent? Because the physical sciences and mathematics have had a constant-dollar decrease of 14 percent during those years. That trend, along with advances being made in these disciplines and considerations of national needs, dictated a special thrust in NSF's budget for the physical sciences and mathematics.

Another special thrust in our budget is engineering, which will receive a 28-percent increase for electrical, computer, and systems engineering research. You also will find large increases for other engineering science activities of the Foundation.

Why? I said a moment ago that Federal basic research in engineering had a 22-percent real growth between 1967 and 1980. But funding of university-based engineering research did not fare so well. The fiscal year 1981 budget shows a clear concern for strengthening the basic research activities in the schools of engineering; it is becoming particularly evident that the station must have strong engineering programs in the universities.

The budget also provides increases for several special programs. One is the industry-university cooperative research program. We are proposing a significant effort, approximately $30 million, devoted to joint research efforts by university and industry scientists. The need for such joint efforts has been evident for some time now, and NSF called attention to it by setting up a formal program about 2½ years ago. The program has gone well; the quality and excellence of the work supported by NSF attracted support from the President's review team. That is why the budget contains a large increase for the program.

The other special program involves small business. There is a significant increment for the support of innovative work by small research firms.

NSF's budget also mentions the President's plans for a cooperative program of basic research related to the automobile. The program would be funded from the proposed energy windfall profit tax. We anticipate that NSF would get between $8 million and $10 million for support of basic research in this area.

I also want to call your attention to the plan for an ocean margin drilling program. It is a major, 10-year undertaking that will require a total of $700 million. The program is to be a cooperative effort by the Government and the petroleum industry, with major petroleum companies putting up half of the research funds. But control and planning of the program will be determined by scientific considerations and managed by the National Science Foundation.

I should call your attention to the international science effort where NSF requests about $3.2 million to continue the U.S.-U.S.S.R. cooperative research program and $2 million for the United States-China program, which has just begun. I would be happy to talk about both efforts.

Let me conclude by commenting that it was 35 years ago, almost to the month, that President Roosevelt asked Vannevar Bush, during World War II, to draw plans for the role of science in the postwar period. The volume that represented his report, "Science, the Endless Frontier," advocated Government support for scientific research and first suggested that there be a National Science Foundation. I believe that the report's findings are as valid today as ever before.

Professor Paul Samuelson of MIT, a Nobel prize winner in economics, recently summarized the arguments on the role of science in U.S. productivity when he wrote:

> More than half of the growth in U.S. productivity is due to the advance of scientific knowledge, quite aside from society's laborious thrift and sacrifice of current consumption standards in the interest of more productive capital for the future.

You have heard me talk about this issue at previous hearings. It is increasingly evident that a stronger relationship is being established between investment in scientific research and U.S. productivity.

Mr. FUQUA. Thank you very much, Dr. Atkinson.

[The statement of Dr. Richard C. Atkinson, together with related materials, follows:]

STATEMENT BY DR. RICHARD C. ATKINSON
DIRECTOR, NATIONAL SCIENCE FOUNDATION

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

JANUARY 30, 1980

I am pleased to appear before this Committee today to present the programs of the National Science Foundation for fiscal 1981, and to discuss some of the broad trends that we perceive in science and technology and some of the major external factors affecting science and the Foundation's role today.

Any discussion of the internal trends in science and technology and the external forces affecting it must recognize the interplay between science and society. Science has its own internal imperatives, dictated by new opportunities and advances in the disciplines. It is also, however, profoundly influenced by society's expectation that science contribute to the solutions of many of our problems. The National Science Foundation plays an imporant role at the intersection of these forces, having major responsibilities in both directions.

This is a particularly exciting and challenging time both from the perspective of the developments that are occurring in science and from the perspective of society's need to use science in solving major problems. Science has a vital role to play in this decade and beyond.

Thirty-five years ago, the Vannevar Bush report, Science -- The Endless Frontier, laid the groundwork for post-war cooperation between science and government. It is striking to be reminded again of how it foresaw today's needs. Its stress on the role of science as one member of a team -- at the same time recognizing that "without scientific progress no amount of achievement in other directions can insure our health, prosperity and security" -- is as valid today as when it was written. Its call for the nation to explore the frontiers of science is as imperative today as it ever was.

IMPORTANT TRENDS IN SCIENCE

There are at least four important trends in science which I see at present. They are internal, in the sense that they are driven by the dynamics of science itself rather than by demands or constraints imposed by society. These trends are:

--- A stronger interdependence among many of the historically well-established disciplines;

--- An increasing convergence of basic and applied science;

--- A rise in joint efforts involving industrial, academic, and other performers of research; and

--- A growth in international cooperation in relation to major research undertakings.

These trends are all healthy, and they furnish new opportunities. They indicate that science is a living thing, changing and developing as it grows, becoming more unified and integrated as it also becomes more complex. Individual scientists become more highly specialized as they pursue the exploration of particular phenomena, but in many areas of science, we are discovering that the theoretical developments in one discipline are applicable to those in others and that hitherto inexplicable phenomena become understandable as this convergence occurs. This is very exciting and productive for the development of new fundamental knowledge as well as new applications.

(1) The Interdependence Among Scientific Disciplines

The scientific disciplines began as separate attempts to understand natural phenomena, and for a long time appeared to be quite different and well-defined areas. Physics began as the study of the motion of bodies. Chemistry was mainly concerned with the properties and combinations of gases and liquids. Biology dealt with living things, and geology with the earth. There was a time when the overlap between these areas was negligible.

Today the line between chemistry and physics in the study and use of lasers has all but disappeared. Biology is increasingly dependent on very sophisticated chemistry, and we find we can't even teach chemistry to undergraduates until they have mastered at least elementary physics.

The situation is even more striking in the newer disciplines. Materials science is heavily dependent on chemistry and physics, and computer science depends on mathematics. The environmental sciences -- oceanography, earth science, and atmospheric science -- are all heavily dependent on chemistry and physics, and to a lesser extent biology. Even the lines of demarcation within the environmental sciences themselves are disappearing, for we now explain the formations of the oceans with the geological theory of plate tectonics, and we know that movements in the atmosphere are dependent on heat transfer in the oceans.

In many ways, old disciplines are changing and new ones evolving. All of this is healthy for it tells us that science is moving closer to the ultimate goal of a unified explanation of phenomena in very different realms. In more immediate terms, however, it means that we must be ready to adjust our support for scientific enterprise to keep pace with this change.

(2) The Convergence of Basic and Applied Research

Until the middle of the nineteenth century, there was very little connection between science -- which involved the efforts of a small elite to understand the world -- and technology, which encompassed the efforts of practical people to solve problems in the real world. In this context, "applied research" simply did not exist. The latter became possible only when science had developed to the point where its insights could be used to imagine, and then to build, technologies which literally were inconceivable without those insights. Science had nothing to do with the development of water-powered mills, for example, for they were things that could be imagined, and thus built, without the help of abstract theoretical insights. But electric motors were entirely different; they had to wait for the formulation of the laws of electricity, for without these theories no one could possibly imagine such a device.

In the little more than a century since science and technology were first linked together, our theories have grown to cover vastly broader ranges of phenomena; our sense of where our technologies are limited because of inadequate knowledge, and how advances in knowledge might lead to new technologies has grown tremendously. Whereas in the past we expected the passage of years or even decades between an advance in fundamental knowledge and a useful application of that knowledge, today we see much shorter time lags, and in some fields discovery and application proceed in a smoothly, articulated fashion.

In materials science, for instance, advances in understanding the behavior of individual atoms on the surface of metals give us some very good leads for techniques to control corrosion -- something that costs the U.S. economy an estimated $70 billion annually. Advances in understanding the crystalline structure of metals -- basic research using the most advanced techniques of high resolution electron microscopy -- have immediate application to improving the strength, fatigue life, and corrosion properties of structural metals.

Our grasp of the geophysical dynamics of the earth has undergone a revolution with the theory of plate tectonics and its confirmation in the ocean cores of the Deep Sea Drilling Project. This, in turn, has enhanced our understanding of the dynamics of earthquakes and climate as well as of the formation and location of fossil fuels and mineral deposits.

Our understanding of the genetic code and developments in recombinant DNA techniques -- work which has only become possible in the last few years -- has the potential for applications of incalculable benefit to mankind. Private industry is already engaged in the production of synthetic insulin, and just this month, the synthesis of human interferon, using recombinant DNA, occurred. This is a major step forward in the search for ways to control viruses, with implications for diseases as varied as cancer and the common cold.

Despite the ever closer link between insight and application, we must continue to distinguish between basic and applied research. It is critical that we not fall into the trap of thinking that an applied approach, driven by the search for a solution to a problem rather than by the development of scientific opportunities, will yield results by itself. The advances I have described all resulted from work directed at understanding, not at finding a solution to a practical problem. But they all had quick and important applications. My point here is simply that while basic and applied research are indeed separate and distinguishable activities, we should expect to see closer linkages between them in the years ahead.

(3) Joint Efforts of Research Performers

Partly in response to these two trends, we have seen a third -- an increased tendency for cooperation between academic and industrial scientists in the performance of research. Industry is mainly focused on application, of course, because it wants a product. As discoveries in basic science have become more relevant to commercial products, industry has turned to academic researchers for help. And academic researchers have sought industrial connections, especially in such fields as engineering and materials science, because industry has special facilities and special knowledge gained frequently from concentrating on "applied" problems.

It is in the public interest that NSF, among other agencies, try to bring the parties together through industry-university programs. But the driving force behind it is really the increasingly tight linkage between basic and applied research. One result has been the proliferation of small, innovative high-technology firms that "spin-off" from the joint research activities of universities and larger firms and that have an important bearing on our productivity.

(4) Science Among Nations

Finally, there is a trend toward increased cooperation in science among nations. This is most evident in "big science," where the problems require observation on a global scale and necessary resources in money and manpower often outrun the capabilities of individual countries. It is especially apparent in the earth, ocean and atmospheric sciences, where programs such as the International Phase of Ocean Drilling, the International Decade of Ocean Exploration, and larger-scale atmospheric research programs have been outstanding successes. But international cooperation on a smaller scale is also increasingly common and mutually beneficial. Collaboration between scientists in different countries is particularly evident in physics, chemistry, biology, anthropology, and in cross-cultural studies in the social sciences. Hundreds of international conferences, workshops, and other meetings take place each year, and the number has increased as Japan and the European countries have advanced their research capabilities. The United States gains from the exchanges with the scientifically developed countries, for it can no longer expect to be totally dominant in every field of science.

We have also seen an increase in bilateral science agreements with countries which are less developed scientifically. Here there are benefits to both sides from such agreements though they may be of different sorts. Our partners seek to improve their scientific capability, which is generally in our interest, and often seek special research opportunities. In some cases, the most important of which is China, we also seek to use cooperation in science and technology as a way to build trust and confidence, and to improve relations generally.

[illegible] EXTERNAL DEMANDS AND CONSTRAINTS ON SCIENCE

(1) Society's Dependence Upon Technological Advance

Just as science has been changing, so has the society in which it operates. Of prime importance is the increasing dependence of society upon the advances of both science and technology. Most of the complex issues facing our nation today possess scientific and technological components. No longer can we say, as did the Washington Post editorial of January 1, 1880, that "We can count up on the fingers of one hand all misfortunes of national magnitude. Beyond the yellow fever at Memphis and the outbreak among the Indians, there has been nothing serious." As the urgency of problems has risen, society has responded by actively searching for new knowledge, rather than waiting passively for the private sector to develop it. Society needs technological advances, and technology needs science. It is this dependence which has led to increased links between basic research and applications, including a particular emphasis in the Foundation's programs on finding ways to increase innovative developments in industry and agriculture,

(2) Technological Competition Among Nations

The important role that science and technology have come to play in international affairs will increase during the decade. One of the outcomes of the increasing strength of science abroad is that technology has become more competitive. The consequences of this for international trade, coupled with indications of declining productivity in U.S. industry, are important external factors affecting American science and technology. Intensive investments in R&D by West Germany and Japan have resulted in high productivity growth rates and leading positions in selected fields. This challenge by other nations to U.S. scientific preeminence is already being translated into severe competition in high technology markets.

(3) Accountability and Relevance

There are increasing pressures upon science for relevance and accountability. Some individuals question the use of public funds to support projects, however legitimate scientifically, which appear esoteric and of no readily apparent relevance to national concerns. Others ask for more accountability from science for public funds through oversight.

Accountability in the use of public funds is an important aspect of the relationship between science and society. The balance between appropriate safeguards for the use of public resources and reporting requirements that are costly and burdensome is a delicate one. Both the Congress and the Administration have expressed concern about this balance. The Foundation is experimenting with ways to make oversight of its research projects cost-effective, while, at the same time, recognizing its responsibility in using public funds.

In part, the relevance of science to life today has increased the public's expectations of what science should accomplish. Yet it is the unpredictable nature of the frontiers of science where, by definition, we do not know what the next step will bring, that contains both the challenges and the rewards of basic science. Across the entire range of science today, discoveries with enormous immediate social relevance are occurring. For example, the term biotechnology was unknown a few years ago. Had scientists been constrained to short-term attacks on problems of food production, finding new sources of alcohol, producing scarce disease-fighting substances, encouraging productivity, they would never have discovered the techniques of recombinant DNA. Yet, those techniques, developed out of basic research at the frontiers of biology, are already being put to use in all these respects.

We can, however, spell out certain areas of national concern where science has a special relevance in the decade ahead. The first Five-Year Outlook on science and technology, which the National Science Foundation is now completing, does just this -- it assesses the capabilities of science and technology to contribute to the resolution of issues of national importance. Four broad issues, discussed in detail in that report, illustrate the nature of the challenges that American science and technology face during this decade.

> Innovation and Productivity. The relationship between R&D and productivity is of crucial importance in times of inflation. It has been statistically demonstrated by Dr. Robert Solow of M.I.T. that more than half of the growth in U.S. productivity is due to the advance of scientific knowledge, quite aside from any sacrifice of current consumption in the interest of capital formation. The President's Domestic Policy Review on Industrial Innovation Initiatives recommended "first steps in meeting the nation's commitment to innovation and the continuing challenge to maintain the technological strength of the American economy." Included are three major initiatives for NSF that build on our experience in supporting research and engineering in both academic and industrial organizations.
>
> Ensuring Adequate Supplies of Energy and Other Nonrenewable Resources. This nation's industrial growth has been based on the ready availability of low cost energy and other material resources. Worldwide shortages of petroleum will become increasingly severe during the remainder of the century. We need to take steps to reduce our dependence on foreign petroleum sources to develop environmentally safe alternatives. Science and technology have a key role to play in a number of areas

The ocean margin represents the largest scientific unknown in geology today and also the largest unexplored area where we might expect to find hydrocarbons. Better technologies for understanding the geological formations in this area, a necessary prelude to evaluating the resource potential, are needed. The Administration's proposed Ocean Margin Drilling Program, to be managed by NSF, is directed at this goal.

Improving the Science and Technology Base for Risk Assessment. Science and technology often are crucial in the identification of policy issues, in making decisions about environmental standards, and in assessing the risks of new technologies. If regulations are to become more rational, we must expand the science on which regulations are based. The task is complicated by differing opinions of how much risk is acceptable for a particular level of benefit. The long-term social costs of foreclosing promising technological options by stringent environmental regulations is a particularly crucial area.

Contributions to Improvements in Health. Access to high-quality health care for all Americans will receive considerable attention during the coming years. With the reduction or elimination of many infectious diseases and improvements in nutrition and sanitation, the longevity of Americans has increased during this century. But this, in turn, has magnified the seriousness of non-infectious diseases common to middle and old age, such as heart disease and cancer. Science and technology can contribute to better health by advancing our understanding of diseases; by expanding our knowledge of the effects of life-styles on health; and by enhancing the effectiveness of medical interventions.

NSF ROLE

NSF must be adaptive in order to carry out its role of seeing that science advances in the direction of the greatest research opportunities while ensuring that science contributes to the national welfare. This need for adaptiveness was anticipated by the authors of the NSF Act. They formulated an Act that is broad and flexible -- that permits the Foundation to accommodate both the internal imperatives of science and the demands of society.

The nation's investment in R&D provides the overall context for the NSF role. In the mid-seventies, total national expenditures for research and development in the United States -- including investments made by both the public and private sectors -- began to show real growth for the first time in ten years. They are projected to reach a current dollar level of $57.3 billion in 1980. Of course, this figure includes many development projects, notably in defense, energy, and space. In constant dollars, overall R&D expenditures increased at an average annual rate of about 3.4% during the last half of the 1970's. This growth has resulted in large part from increased emphasis on finding alternative energy sources.

Expenditures for R&D by private industry have been increasing more rapidly than Federal Government expenditures and are now approximately equal to them. The increase in the industrial sector has related particularly to energy and environmental matters.

During the 1975-80 period, funding for both research and development increased at the same rate of 3.4%. Within research, however, there has been a trend, led by the Federal Government, of allocating proportionately more funds to basic research. At present, the Federal Government supports about two-thirds of the nation's basic research and one-half of the applied research.

In this regard, support for research and development and, specifically, for basic research has been a policy of this Administration. President Carter's Science and Technology Message to the Congress articulated a policy of increasing federal support for basic research and, where appropriate, for the development of new technologies. This policy has been reflected in the Administration's request for real increases in federal appropriations for basic research in its first three budgets. Continuing high inflation rates have mitigated the anticipated effects of these increasing investments. Nevertheless, federal support for basic research, measured in constant dollars, has shown real growth. The President's State of the Union Message on January 22 reaffirmed this policy and specified further initiatives under it for 1981.

The National Science Foundation has come to play an increasingly important role in the Federal Government's programs of research support. In specific terms, NSF now provides about one-fourth of all federal support for basic research -- up from 14% in 1969. In the nation's colleges and universities, NSF now provides about 35% of all federal funds for the conduct of basic research compared to 26% in 1969.

The Foundation is unique in the Federal Government in that it is the only agency responsible for supporting research in all fields of science and engineering, and science education. Its efforts are designed to support the development of the knowledge, tools, and skills across all fields of science that make it possible for the nation's problem solving institutions -- in both the public and private sectors -- to carry out their tasks imaginatively and effectively. Nevertheless, it is crucial that we recognize the importance of a multiciplicity of both funding sources and performers in maintaining the effectiveness of our scientific enterprise. With respect to the mission agencies, it is important and necessary that their support of basic research continue to underpin their applied research and development activities in carrying out the specific missions mandated by Congress.

Within this context, NSF is requesting $1,148 million for fiscal year 1981. The specific emphases in the budget reflect many months of deliberation and exchange of views and recommendations on the part of the National Science Board, the Foundation staff, advisory committees, the Office of Science and Technology Policy, and the Office of Management and Budget. Planning for this budget began in earnest almost 20 months ago, at the June 1978 meeting of the National Science Board, and the balancing of priorities has continued down to the last possible moment. Concerns for the nation's future and for the taxpayer's dollar have weighed heavily in these decisions.

The significant features of the budget include:

--- A proposed increase in basic research in recognition of the need for the U.S. to continue a rapid pace of advance of fundamental understanding in science and engineering. The results of research in mathematics, chemistry, physics, engineering, materials research, and computer science have high potential for contributing to improved technology and productivity, both essential in our efforts to promote economic growth and sustain our international balance of payments. This increase in the physical sciences underscores this contribution.

--- As part of its desire to facilitate the movement of basic research concepts to practical application, NSF combined its engineering and science applications activities into a single directorate in FY 1980. Engineering research and applied areas of science, especially computer sciences and applied chemistry have been greatly strengthened as part of an effort to expand research that has a high potential for the solution of societal problems in such areas as transportation, energy, environment, new and improved technology and food and nutrition.

--- An Administration's emphasis on the need for programs to enhance industrial innovation resulting in several major efforts in the FY 1981 budget.

. Industry-University Cooperative Research. A special challenge for the U.S. is to utilize fully the research capabilities of industry and universities in efforts that can lead to a strengthened, more vigorous U.S. research effort. Concern about international competition has contributed to proposals for enhanced teamwork between universities and industries that will lead to the development of new products and improved services. The NSF in FY 1981 is proposing to increase its Industry/University Cooperative Scientific Research activity by more than $20 million. These efforts are designed to couple more closely the activities of industries and universities. They will also help provide appropriate incentives to ensure that there are improved opportunities for university and industry research laboratories to keep American science at the cutting edge of progress, thus giving our industries a technical edge in the worldwide competitive government.

- Small Business Research Efforts. NSF is also moving aggressively to strengthen research which provides opportunities for small firms to make valuable contributions to the national research effort in FY 1981. The Foundation is requesting that this program be augmented by $10 million for this purpose, bringing the total amount for small business participation, primarily in applied efforts, to approximately $13.5 million.

- Generic Technology Centers. NSF plans to establish another technology center, similar to the MIT Polymer Center, as part of a program of developing and transferring to the private sector generic technologies that are common to several industrial sectors. The focus will be on technologies that have the potential for significant upgrading of technological processes. The centers will be developed as part of a larger federal effort that includes the Department of Commerce, and will be jointly funded by industry and government.

--- A major government-industry initiative known as the Ocean Margin Drilling Program. The FY 1981 budget request includes $10 million, to be matched by an equal amount from a number of U.S. petroleum companies, to embark on a 10-year program of drilling in the Ocean Margin, where more than half of the world's marine sediments have been deposited. The United States has more than 7.5 million square miles of combined continental shelf and slope, of which only about two percent has been drilled even in an exploratory fashion. This includes areas near the Atlantic coast, some parts of the Pacific coast, coastal Alaska, the Gulf of Mexico, and the Bering Sea. While little is known of the geologic structures and character of the sediment in these regions, there is much evidence that there is good potential for oil and gas. Scientifically, the program would aim at some of the most basic questions in geology, including those related to continental break-up and ocean basin formation. Studies will begin to establish a geological framework for the thick sedimentary sections of the margins that hold promise of natural resources. Technically, it would involve considerable extension of offshore drilling practices, possibly through conversion of the Glomar Explorer to this purpose. Economically, it would provide the scientific basis for a future assessment of the potential of natural resources of the ocean margins.

The FY 1981 request includes $10 million to start this program, which is to be matched by an equal amount contributed by oil companies. This first year funding will allow completion of the engineering design and cost estimates for conversion of the Glomar Explorer or other possible platforms and for initial implementation of the program.

--- The Foundation recognizes that research instrumentation and facilities go hand-in-hand in the creation of new knowledge. And yet, obsolescence and deterioration of instrumentation in many of the nation's research centers and educational institutions hamper the pursuit of knowledge. To deal with this serious problem the NSF provides support for a variety of research facilities and research equipment and instrumentation that are essential to the performance of scientific research. Part of the NSF response to the increasing equipment needs of the research community was the creation of the Regional Instrumentation Centers program; targeting of some support for two-year and four-year colleges; and the Biological Instrumentation program to complement a similar program in Chemistry. In FY 1981, as part of its overall instrumentation and equipment funding, NSF is initiating a competitive program to modernize and upgrade university research facilities. All of these efforts are designed to increase the cost-effectiveness of scientific **efforts** and ensure that the cutting edge of research is carried forward vigorously.

--- As the technology base of the U.S. has grown, the traditional NSF role in science education to stimulate and develop talented science students has changed. Supplementing traditional goals worthy of continued support, it is clear that we must also address the needs of special constituencies that have been underrepresented in earlier years and improve the understanding of science by all citizens.

To accomplish these diverse aims special science education effort is being placed on: (1) science education for the early adolescent; (2) improving access to careers in science, particularly for minorities, women and the physically handicapped; (3) technology as applied in learning sciences; and (4) increasing the general science literacy for our entire society.

Mr. Chairman, this concludes my remarks to you and your Committee. I shall be happy to respond to any questions you may have.

National Science Foundation

WASHINGTON, D. C. 20550

BUDGET IN BRIEF

Fiscal Year 1981

TO
THE CONGRESS

NATIONAL SCIENCE FOUNDATION

Director's Statement

We enter this decade with a keen awareness that science has a vital role to play in the years ahead. Our nation's future is closely tied to the strength of our scientific enterprise. In such essential areas as food for the world's growing population, new sources of fuel to replace dwindling oil reserves, the fight against disease, and the assurance of adequate national security, we are profoundly dependent on the new knowledge and technologies that grow out of scientific research. Beyond these fundamental concerns, science must provide the technological development necessary to maintain our economy in the face of increasing competition from abroad and must show us how to protect the life-giving balance of the planet.

The past 10 years have been a time of extraordinary activity in science, with the pace of discovery being described as "explosive" in many fields. In the macro laboratory of outer space, startling discoveries that add to the clues about the origin of the universe have been made. At the micro level, our understanding of the basic building blocks of atomic and molecular structure has advanced rapidly with the aid of new sophisticated tools such as lasers, synchrotron radiation sources, and high-speed computers.

Our grasp of the geophysical history and dynamics of our planet has undergone the greatest revolution since Copernicus with the theory of plate tectonics and its confirmation in the ocean cores of the Deep Sea Drilling Project. This, in turn, has enhanced our understanding of the dynamics of earthquakes and climate, as well as of the formation and location of fossil fuel and mineral deposits on land and under the sea. The deciphering, just ten years ago, of the genetic code for DNA and RNA has led to a ferment of activity in cell biology and immunology. This same decade has witnessed a remarkable expansion in the computer sciences, as pure mathematical theories have been combined with the silicon chip to advance the solid state technology of high-speed computers. Whole new fields of science have emerged, while the boundaries separating others have begun to disappear. Research cutting across disciplinary lines has increased, a reliable sign of vitality in science, and there has been a convergence of the sciences of living and non-living matter.

New basic knowledge today often has quite immediate implications for society. Our understanding of the genetic code has great significance for agriculture and medicine, is making possible previously unimagined industrial technologies, and may even create new energy sources. Private industry is already engaged in the production of synthetic insulin and interferon, using recombinant DNA techniques, and similar techniques are being applied to the study of nitrogen fixation in plants. New knowledge of the earth's crust not only has laid the basis for further work in the continental margins, of great scientific importance, but also has direct and immediate application to the search for oil. Research on the chemistry of the upper atmosphere has made us aware of potential long-term changes in the ozone shield that can have significant consequences for our health and, ultimately, for life on Earth. With advances in computer and materials sciences, we are now able to install a complete microcomputer on a single chip, a fraction of the size of a thumbnail, while the cost of a chip has remained almost constant. Still further dramatic advances lie ahead with immediate relevance to our productivity and international trade. For example, organic compounds have been prepared with electrical conductivities approaching that of copper.

This drawing together of basic and applied research is not merely fortuitous—rather, it reflects the increasing role of science and technology in all aspects of our daily life and the growing urgency of national problems containing significant scientific components. In any event, it cannot be said that scientific knowledge today consists of dusty reports lying forgotten on a library shelf—too many people are eagerly awaiting the latest developments in fundamental knowledge.

These developments in the seventies have been possible because of the Nation's investment in basic science and in the training of scientists over the past 35 years. An important result of that investment has been the availablility to scientists of a remarkable array of instruments, from laboratory spectrometers to radio and infrared telescopes, from picosecond time measurements to remote sensing satellites, from lasers to synchrotron radiation facilities, from ever-smaller to ever-faster, more powerful computers. On both the macro and micro levels, this instrumentation has given scientists access to new realms of the universe. The seventies have shown us how important this access is to advances in scientific theory and application.

Just as science has been changing dramatically, so has the society in which science operates. The growing complexity and interdependence of our cultural institutions have placed new demands on science and new responsibilities on government. No longer can we say, as was said 100 years ago in the *Washington Post* editorial of January 1, 1880, that "We can count up on the fingers of one hand all misfortunes of national magnitude. Beyond the yellow fever at Memphis and the outbreak among the Indians there has been nothing serious." As science has increased the options for dealing with challenging problems, society has responded by actively reaching for new knowledge, rather than waiting passively for the private sector to develop and use it. The challenge today is to further an active partnership of government, the universities, and industry in supporting research. NSF and the Administration expect to play leading roles.

Thirty-five years ago the Vannevar Bush report, *Science—The Endless Frontier*, laid the groundwork for the post-war cooperation between science and government. It is striking to be reminded again how it foresaw the needs of today. Its stress on the role of science as one member of a team, at the same time recognizing that "without scientific progress no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world," is as valid today as it was when it was written. Its call for the Nation to explore the frontiers of science is as imperative today as ever.

Finally, there have been important developments in the National Science Foundation during the 1970's, and the fiscal year 1981 budget builds on these developments. Despite record inflation in recent years, there has been real growth in the Foundation's research budget during the 1970's, although this has, unfortunately, been offset in many areas by a decline in basic research support by other Federal agencies. NSF support has played a major role in the dramatic developments mentioned earlier. During the seventies, the search for fundamental knowledge was singled out by each Administration as being increasingly important to the Nation. Most recently, the President's Science and Technology Message of 1979 noted that "most of the great undertakings we face today as a nation have a scientific or technological component."

NSF's applied research effort was formally initiated at the beginning of the decade, building on the Foundation's extensive programs in the physical, biological, and behavioral sciences, and engineering. This marked the beginning of NSF support for applied research in universities and nonprofit organizations and also in industry when the research addressed critical national problems. The new effort stressed interdisciplinary research and cooperation among different types of organizations—university, industry, and State and local government. The inclusion of engineering in a recently-created Engineering and Applied Science Directorate is intended to stimulate still further interaction between basic and applied programs and among different types of research performers, the value of which has proved so important to the vitality of our scientific enterprise.

Other developments of the seventies included increased Foundation support for the social sciences and a recognition that this area of science is coming of age. Congressional amendments to the NSF Act in 1968 made explicit the Foundation's mandate to support the social sciences. Today, NSF is the only agency of the Federal Government with the mission to support basic research in the social sciences and carries almost the entire responsibility for Federal support for this field. The importance of this support is amply demonstrated, for example, by the work of Nobel laureates in economics who have received NSF grants.

A significant growth in international cooperation in science also marked the decade just ended. Bilateral scientific and technical agreements were signed with many countries. The increased exchange of scientific and technical information laid the groundwork for many other types of exchange and communication. The most recent agreement with the People's Republic of China contributed to improved relations with that country. The National Science Foundation has been responsible for implementing over twenty of these agreements on behalf of the U.S. Government.

Science has always been international in nature, as basic knowledge transcends national boundaries. A growing number of larger cooperative undertakings with other nations occurred in the seventies, many of them managed by NSF. This increase in large international undertakings has been due, in part, to the global nature of many scientific efforts, such as studies of the world's oceans and atmosphere, and in part to new developments in instrumentation which enable us to study these phenomena. The International Biological Program, the International Decade of Ocean Exploration, the Deep Sea Drilling Project, and the Global Atmospheric Research Program are some of the significant larger-scale undertakings of the seventies by NSF. In the 1970's, NSF also assumed full responsibility for managing the U.S. Antarctic program, which encompasses a broad range of scientific research in the physical and biological sciences and involves cooperation with other signatory nations of the Antarctic Treaty. At home, NSF's management of the construction of the Very Large Array radio astronomy facility, initiated in the seventies, extended capabilities for ground-based astronomy. The Foundation continues as lead agency for ground-based astronomy that it supports at several national centers and observatories.

During this decade, as school enrollments declined and the need to implement real growth in the Nation's fundamental research assumed higher priority, funding of NSF science education programs declined relative to the overall budget. Increased attention was directed at research in science education to improve its effectiveness, and, at education for non-scientists, to increase the public's understanding of science. There has been a particular focus on the junior high school level, since this is where general scientific literacy can be increased and where important choices occur on the road to science careers. Special attention has also been given to increasing the participation of women and minorities in science to reduce the significant loss of talent to the Nation from their underrepresentation in science careers. The link between research and teaching in science and the effectiveness of NSF's science education programs over the years played an important part in the decision to transfer only a small portion of the Foundation's education programs to the new Department of Education.

The NSF budget request of $1,148 million for fiscal year 1981 builds on our extensive experience of supporting scientific research and science education in a variety of organizations over the past 30 years. The specific emphases in the 1981 budget reflect many months of deliberation and exchange of views and recommendations on the part of the National Science Board, the Foundation staff, advisory committees, the Office of Science and Technology Policy, and the Office of Management and Budget. Planning for this budget began in earnest almost 20 months ago, at the June 1978 meeting of the National Science Board, and the balancing of priorities has continued down to the last possible moment. Concerns for the Nation's future and for the taxpayer's dollar have weighed heavily in these decisions.

While NSF is not among the largest R&D agencies, the NSF Act places upon it the key responsibility for strengthening the scientific enterprise, nationwide; for fostering the highest calibre of scientists and engineers; and for encouraging the application of science to national concerns. The 1981 budget has been developed with this in mind.

Richard C. Atkinson

Richard C. Atkinson
Director

January 28, 1980

National Science Foundation

Washington, D.C. 20550

FY 1981

Budget in Brief to the Congress

NEW OBLIGATIONAL AUTHORITY:	
FY 1981 Budget Request	$1,148,000,000
FY 1980 Appropriation (P.L. 96-103)	996,250,000
Proposed Supplemental[1]	.840,000
Less Transfer to Department of Education	-6,584,000
FY 1980 New Obligational Authority	990,506,000
Increase in New Obligational Authority FY 1981/FY 1980	157,494,000
PROGRAM LEVEL:	
FY 1981	$1,148,000,000
FY 1980:	
Prior Year Carryover[2]	3,343,893
Proposed Pay Supplemental	.840,000
FY 1980 Appropriations	996,250,000
Transfer to Department of Education	-6,584,000
FY 1980 Program Level	993,849,893
Increase in Program Level FY 1981/FY 1980	154,150,107

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[1] Provides for increased pay costs of Antarctic logistics support.

[2] Includes $2.5M PD&M carryover earmarked for October 1979 pay raise per House Appropriation Subcommittee guidance.

ABOUT THE NATIONAL SCIENCE FOUNDATION—

The National Science Foundation is the principal Federal agency for the support of basic research across all fields of science and science education at universities and colleges. NSF accounts for about 34 percent of all Federal support for basic research going to academic institutions. In some fields, NSF provides the dominant share of Federal basic research support: more than 69 percent in ground-based astronomy, 60 percent in environmental sciences and over 50 percent in mathematics and engineering.

More than 2,000 colleges, universities, industrial firms, and other institutions and organizations participate in NSF programs. Additionally, over 200 small business firms are involved in NSF supported research, mostly in applied research areas.

NSF is an independent Federal agency. It accomplishes its mission primarily through grants and contracts. It operates no in-house laboratories.

The Foundation was established as an outgrowth of President Franklin D. Roosevelt's desire for a science agency that could contribute to a peacetime economy by enhancing U.S. scientific strength. In 1944, President Roosevelt instructed Dr. Vannevar Bush, then Director of the Office of Scientific Research and Development, to find a way for the Nation to benefit from science in peacetime as it had in wartime and to assure U.S. scientific strength for reasons of national prosperity and security.

Dr. Bush's report, *Science, the Endless Frontier*, led to the establishment of the National Science Foundation. President Harry S Truman signed the NSF Act in 1950. NSF's mission under the Act is to strengthen U.S. science and engineering through the support of basic research and science education programs.

In 1968, the NSF Act was amended to give the agency additional authority to support applied research and to clarify and strengthen the Foundation's responsibilities in science education, international cooperative science, and science policy. NSF is responsible for strengthening science education at all educational levels.

NSF determines the quality of research and science education projects through a system of peer review. More than 30,000 scientists, engineers, and science educators in all parts of the United States participate in the NSF peer review process each year. They provide a yardstick for excellence, giving their views and evaluations of proposed projects. NSF staff members who are experts in science, engineering, or science education make the final decision on awards.

Through contracts with universities or university consortia, NSF supports several national research centers. These include the National Center for Atmospheric Research, Boulder, Colorado; Kitt Peak National Observatory, Tucson, Arizona; Cerro Tololo Inter-American Observatory, Chile; National Radio Astronomy Observatory, Green Bank, West Virginia, Kitt Peak, Arizona, and Socorro, New Mexico; the Sacramento Peak Observatory, Sunspot, New Mexico; and the National Astronomy and Ionosphere Center, Arecibo, Puerto Rico. Major facilities also include the National Scientific Balloon Facility, Palestine, Texas; Cornell Electron Storage Ring and the Submicron Research Facility at Cornell University; and the National Magnet Laboratory at the Massachusetts Institute of Technology, among others.

NSF, by law, consists of the Director and the National Science Board. The National Science Board is the NSF policymaking body and has 25 members, including the Director as an ex *officio* member. The Director and Board members are appointed by the President and confirmed by the Senate for 6-year terms. The terms of the Board members are arranged so that the terms of one-third of the members expire every two years.

The present Chairman of the National Science Board is Dr. Norman Hackerman, President of Rice University. The NSF Director is Dr. Richard C. Atkinson.

The Foundation has about 1,274 employees. The Director, Deputy Director, and four Assistant Directors are appointed by the President and confirmed by the Senate. Three other Assistant Directors are appointed by the NSF Director. More than 30 percent of the NSF staff are experts in the various fields of science, engineering, and science education. About five percent of the staff are scientists serving as "rotators" from academic and other nongovernmental institutions. These rotators work for the Foundation for 1 or 2 years and then return to their home institutions. They help provide a continuous influx of up-to-date information and fresh viewpoints on the needs and opportunities for science and science education.

NSF Responsibilities

- Strengthen basic research in the mathematical, physical, environmental, engineering, biological, social and other sciences.
- Initiate and support applied research at academic and nonprofit institutions and at profit-making and other appropriate organizations.
- Strengthen science education programs at all levels.
- Stimulate international scientific cooperation between U.S. and foreign scientists.
- Increase U.S. research potential through cooperative industry/university research.
- Assist in providing the Nation with highly trained scientists and engineers through a program of fellowships for science and engineering.
- Gather and publish scientific and technical data pertinent to national science policy decisionmaking.
- Manage and fund the U.S. Antarctic Program.
- Recommend and encourage the pursuit of national policies for the promotion of basic research and education in the sciences.

NATIONAL SCIENCE FOUNDATION
FY 1981 BUDGET IN BRIEF

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NATIONAL SCIENCE FOUNDATION
TOTAL DOLLAR SUMMARY
FY 1979 - FY 1981

(Millions of Dollars)

Source	FY 1979 Actual	FY 1980		FY 1981 Budget Request to Congress	Difference FY 1981 Request/ FY 1980 Plan
		Budget Request to Congress	FY 1980 Plan Based on Actual Legislation		
New Obligational Authority	911.0	1,006.0	[1]990.5	1,148.0	157.5
Carryover	15.9	—0—	[2]3.3	—0—	-3.3
Total	926.9	1,006.0	993.8	1,148.0	154.2

[1] Includes proposed supplemental of $840,000 for increased pay costs of Navy personnel engaged in the U.S. Antarctic Program and excludes $6,584,000 transferred to Department of Education.

[2] Includes $2.5 million carryover earmarked for October 1979 pay raise.

NATIONAL SCIENCE FOUNDATION
BUDGET SUMMARY

(Millions of Dollars)

Budget Activity	FY 1979 Actual	FY 1980 Program Funded by Congress	FY 1980 Prior Year Funds Carried Over	FY 1980 Current Plan	FY 1981 New Obligational Authority	Differences: New Obligational Authority FY 1981-80	Differences: Total Program FY 1981-80
Research and Related Activities Appropriation:							
Mathematical and Physical Sciences	$208.9	$226.2	$.2	$226.4	$264.2	$38.0	$37.8
Astronomical, Atmospheric, Earth, and Ocean Sciences	211.6	217.9	—0—	217.9	241.3	23.4	23.4
U.S. Antarctic Program	51.1	55.8	—0—	55.8	63.4	7.6	7.6
Ocean Drilling Programs	11.6	19.5	—0—	19.5	27.3	7.8	7.8
Biological, Behavioral, and Social Sciences	154.7	166.5	—0—	166.5	182.0	15.5	15.5
Engineering and Applied Science	109.9	111.6	.2	111.8	137.0	25.4	25.2
Scientific, Technological, and International Affairs	23.6	26.1	—0—	26.1	28.8	2.7	2.7
Cross Directorate Programs	16.8	25.1	.4	25.5	52.0	26.9	26.5
Program Development and Mangement	54.7	58.1	2.5	60.6	60.8	2.7	.2
Subtotal	$842.9	$906.8	$3.3	$910.1	$1,056.8	$150.0	$146.7
Science Education Activities Appropriation:							
Scientific Personnel Improvement	$33.1	$31.6	—0—	$31.6	$35.2	$3.6	$3.6
Science Education Resources Improvement	28.6	24.0	—0—	24.0	24.2	.2	.2
Science Education Development and Research	12.0	14.9	—0—	14.9	17.5	2.6	2.6
Science and Society	6.3	7.7	—0—	7.7	8.8	1.1	1.1
Subtotal	$80.0	$78.2	—0—	$78.2	$85.7	$7.5	$7.5
Special Foreign Currency Appropriation	$4.0	$5.5	—0—	$5.5	$5.5	—0—	—0—
Total, NSF	$926.9	$990.5	$3.3	[1]$993.6	$1,148.0	$157.5	$154.2

[1] Includes proposed supplemental of $840,000 for increased pay costs of Navy personnel engaged in the U.S. Antarctic Program and excludes $6,584,000 transferred to the Department of Education.

FY 1981 BUDGET OVERVIEW

Amount Requested

The National Science Foundation's FY 1981 budget request is $1,148 million. The request includes $1,056.8 million for Research and Related Activities, $85.7 million for Science Education, and $5.5 million for Special Foreign Currency. The FY 1981 request is $154.15 million or 15.5 percent above the FY 1980 Current Plan of $993.85 million. The overall increase in basic research is 16.9 percent, which takes into account the U.S. Antarctic Research Program and a major initiative in ocean drilling on the continental margins. This budget allows for real growth in the level of effort of most NSF supported activities and is a fiscally sound response to science needs and opportunities.

Research and Related Activities

Research Perspectives

The National Science Foundation supports research in all areas of science and engineering. The bulk of the Foundation's basic research support is provided through individual research project grants in the Mathematical and Physical Sciences; Biological, Behavioral, and Social Sciences; Astronomical, Atmospheric, Earth, and Ocean Sciences; and the Engineering and Integrated Basic Research Programs in the Engineering and Applied Sciences activity. Together, basic research support in these areas increases from $647.2 million to $737.4 million or 13.9 percent.

Basic research remains the essential cornerstone of U.S. science and its support is the prime mission of NSF. Basic Research is the critical building block for new knowledge. For example, fundamental understanding in materials research, electrical and mechanical engineering, neural biology and processes taking place at the submicron level may combine to create an integrated state of knowledge that can lead to benefits for the handicapped through more sophisticated computerized prosthetic devices. Increasingly, advances in science are interdependent. A breakthrough in a seemingly esoteric area of mathematics or physics can trigger new avenues of research in other areas such as chemistry, biology, and astronomy, and the reverse of this phenomenon is also true.

In FY 1981 the Foundation's basic research effort is designed to keep supporting science at a pace that will continue to give the U.S. a scientific edge among the nations of the world. It involves a new dimension in experimental computer research, accelerated research in mathematics and chemistry, strong support for research on microstructures, and expanded efforts in the neurosciences and on ecosystems and other areas of environmental research. The program also provides for the first major step leading to the construction of new 25-meter diameter millimeter wave telescope for astronomy research.

Overall, basic research in the physical sciences and engineering is setting the pace for the NSF program in FY 1981. Basic research is of extreme importance in providing the fundamental knowledge in mathematics, astronomy, physics and other science areas to strengthen and extend the base of scientific knowledge necessary for future progress. In such areas as computer science, chemistry, and materials research, it also holds promise for advances that can lead to practical applications.

NSF-supported basic research is conducted primarily through universities and other research institutions in every State and through various international cooperative science programs on all continents of the world. Several national research centers supported by NSF are available to outstanding visiting scientists on a competitive basis and provide these scientists with access to some of the Nation's most advanced instruments and facilities.

NSF also provides support for applied research in selected areas where there is good potential for the research results to contribute over the long term to improved technology and productivity, both essential in our national efforts to deal with inflation and to provide more and better jobs for U.S. workers. A significant part of NSF applied research deals with fundamental research aimed at expanding our understanding of phenomena and processes. Consequently, NSF applied research is a step removed from specific field applications, demonstration, and development which are the appropriate responsibility of mission agencies and industry.

Other Budget Highlights

In addition to the increases in various areas of basic research described above, the following special thrusts and emphases deserve particular consideration.

Industry/University Cooperative Research—A special challenge for the U.S. is to utilize fully the research capabilities of industry and universities in activities that can lead to a strengthened, more vigorous U.S. research effort. International competition and the practice of other industrialized nations that combine the resources of industry, universities, and the government in concerted R&D efforts in certain markets have created new challenges for America. This competition demands more cooperative efforts among industry, universities, and government to increase U.S. productivity and improve services. The NSF, in FY 1981, in response to a Presidential directive, is increasing its industry/university cooperative research efforts markedly. These efforts are designed to stimulate the research programs of both industry and universities. They will also help provide appropriate incentives to ensure that there are improved opportunities for university and industry research laboratories to keep American science at the cutting edge of progress, thus giving our industries a technical edge in worldwide competition.

Small Business Research Efforts—NSF is also moving aggressively to strengthen research directed at increasing the opportunities for small businesses to make greater contributions to the national research effort in FY 1981. The Foundation's program has been augmented by $10 million for this purpose, bringing the total amount for small business participation, primarily in applied research efforts, to approximately $13 million.

Technology Centers—There are a variety of areas which require advances in science and engineering to enhance our technological capabilities. Corrosion prevention and control, high impulse welding and joining, non-destructive testing and various other so called "generic" technologies require further advances to improve substantially our present technology capabilities. In many of these generic areas advances depend on sophisticated understanding of materials, surface corrosion, and heat transfer. The Foundation will establish one or more generic technology centers in FY 1981 as part of a larger Federal effort designed to enhance technology in basic science and engineering. The centers will be jointly funded by industry and government, and substantial public benefits are expected.

Improving University Research Laboratories—The FY 1981 program request includes $14.25 million to upgrade university research laboratories. Many of these laboratories have outdated facilities which limit the research techniques or instrumentation which can be used. This frequently results in less than optimal return on the investment of Federal dollars for support of research. The FY 1981 budget request represents a begining to alleviate this situation. This is planned to be a matching grant program where Federal funds will be matched with an equal amount of non-Federal funds from academic institutions.

Interagency Cooperation and Science Policy—In recent years, the Foundation has substantially expanded its efforts to improve the effectiveness of cooperation with other Federal agencies. This has been accomplished through a variety of mechanisms, including formal and informal interagency coordinating committees and panels. Perhaps the most effective mechanism is the continual, day by day consultation among program officers in the various agencies. There is also a vastly expanded effort to extend cooperation in the field of science education, with a view toward aiding in the establishment of the new Department of Science Education.

NSF also provides important science policy analyses and science manpower studies that are beneficial to the entire scientific community and to various government agencies, the Congress, and the President's Science Adviser.

International Science Activities—Many NSF science activities are international in scope, and international cooperation through science has become increasingly important in the past decade. In FY 1981, the Foundation will establish a promising cooperative research effort with the People's Republic of China. NSF also hopes to increase its cooperative work with the advanced countries of Western Europe. Our experience in the Antarctic for the past 24 years has demonstrated that science can maintain an effective means of interchange and friendly communication even in times of severe political stress among nations. NSF hopes to continue to conduct a wide range of research support activities that involve the cooperation of many nations in all parts of the world and will continue its effort to enhance U.S. science for the benefit of all peoples.

Ocean Margin Drilling—The FY 1981 budget request includes $10 million, to be matched by the U.S. petroleum industry, to embark on a 10-year Ocean Margin Drilling Program. The scientific results from this program are expected to be as revolutionary in scope as those from the NSF funded Ocean Sediment Coring Program. Further light will be shed on continental drift and the history of the continental margins. Significant new drilling capabilities under the ocean should result from this project. It should also provide knowledge of the geologic framework for passive margins, specifically the U.S. Atlantic margin that contains potential petroleum reserves.

The likely drilling platform is the U.S. Government owned ship, the *Glomar Explorer*. In FY 1981 engineering design and cost estimates for conversion of the *Glomar Explorer* and the advanced deep ocean drilling system, as well as scientific planning, will take place. Results of these efforts will provide the basis for the final "go, no go" decision on the whole project as a joint venture between government and industry.

Science Education—Two NSF Science Education programs, the Minority Institutions Science Improvement program and the Elementary School Science Teacher Training program, are being transferred to the newly established Department of Education. NSF remains a key factor in efforts to strengthen science education at all academic levels. In FY 1981, the Foundation will continue to concentrate efforts at the junior high school level.Experience has shown that large numbers of students, especially minorities and women, drop out of science courses at this level. NSF is determined to tap this potential resource so that minority and women students can have greater opportunities for careers in science and engineering. In addition, the Foundation will continue a range of science education activities designed to stimulate improvements at the graduate and undergraduate level by giving students an opportunity to develop and pursue research and to participate in productive science projects. The Foundation also plans to strengthen its research effort to improve the techniques of science education to make science study more interesting and rewarding.

Special Foreign Currency—NSF has, for several years, undertaken a number of cooperative science programs with nations where the U.S. has local currencies on deposit in amounts declared to be excess to U.S. Government needs by the U.S. Treasury Department. This program has produced beneficial cooperative research efforts with Egypt, India, and Pakistan, and a number of other countries that have given U.S. scientists opportunities for cooperative research otherwise unavailable to them. Excess foreign currencies have also been used effectively in the translation of foreign science journals, text books, and other publications. The use of these excess currencies causes no dollar drain on the U.S. and provides an opportunity for U.S. science to benefit from the use of currencies generated by the sale of U.S. agriculture commodities overseas.

Cross-Directorate Programs—There are several programs of importance to the support of science by the Foundation that do not fit easily into the existing structure of the Foundation. Typically, these programs cut across disciplinary boundaries. To give visibility to these programs and to define more clearly their purposes and explain their need, NSF has combined these programs in FY 1981 into a new program budget activity entitled Cross-Directorate Programs. These include a variety of activities such as the Industry/University Cooperative Research Program, the 2- and 4-Year College Instrumentation Program, the Experimental Program to Stimulate Competitive Research, Research Initiation in Minority Institutions, and the University Research Facilities Improvement Program. These programs generally require special management and review techniques tailored to particular objectives and requirements. By grouping these programs in the Cross-Directorate Program activity, it is expected that the needs and objectives will be clarified to aid the Congress in its consideration of the NSF budget.

Essential Role of Engineering—A widely recognized problem is the lag between basic research and practical application. NSF is uniquely organized to facilitate this movement from concept toward application. It was recognized from the Foundation's beginning that basic research in engineering as well as the sciences is an essential feature of a totally integrated research effort. In recent years it was further recognized that NSF has a role to play in certain applied research and research applications efforts designed to move research results into application in selected areas of national importance. In FY 1980 the Foundation reorganized to combine its engineering and science applications activities into a single directorate.

Engineering retains its basic research characteristics but is now more closely allied with the applications and applied research activities of NSF to improve the flow of basic research results from concept to use.

Frequently, progress in engineering lies in the acquisition of new knowledge from various science disciplines, especially materials research, chemistry and computer science. The Foundation has taken action to strengthen greatly its engineering and applied research areas in FY 1981 as part of a broader agency effort to expand research in fields that have a high potential for contributing to the eventual solution of problems confronting society in such areas as transportation, energy, environment, new and improved technology, and food and nutrition.

SOME MAJOR RESEARCH QUESTIONS ADDRESSED BY NSF SUPPORTED RESEARCHERS

Basic Research

- Can a model be found to predict laser-induced chemical reactions?
- Can a unified theory be found which describes the strong nuclear force, the electromagnetic force, and the weak force as three related aspects of a single force of nature? Can all the forces in nature be described by a single unified theory?
- What are the taxonomic and biological characteristics of organisms in the endangered tropical forests?
- How can the unprecedented complexity and capacity of Very Large Scale Integrated (VLSI) electronics be controlled and utilized to devise new computer concepts, systems, and applications?
- Is gravitational radiation produced by natural astronomical sources? What are its properties? How can it be detected in the laboratory?
- How can certain chemical bonds, such as between carbon-hydrogen or carbon-carbon, be made more reactive at ordinary temperatures and pressures?
- How do internal interfaces, such as grain boundaries, and micro chemical segregation to interfaces affect the mechanical and physical properties of crystalline solids?
- What are the detailed atomic and molecular structures of amorphous (glassy) solids and how does structure affect the magnetic, electronic, and mechanical behavior, and resistance to chemical attack?
- How do plants and animals interact with the atmosphere to (a) control atmospheric carbon dioxide and (b) respond to acid rain?
- What are the detailed reactions going on deep within the Sun? How are these related to cycles of solar activity? Is the Sun cooling down? What can we learn about the interior of the Sun from studies of its surface conditons?
- Do the Sun's variations affect the magnetosphere, ionosphere, upper atmosphere and, finally, terestrial climate and weather?
- By what mechanisms do brain circuits control body temperature, blood pressure, and heart rate?
- What are the factors that control the formulation, organization and decay of convective severe storms?
- What is the geologic structure of passive oceanic margins (such as the U.S. east coast)? Is the geologic picture consistent with the accumulation of petroleum?

- How are earthquakes, volcanic activity and formation of mountain ranges related to plate tectonic processes at active oceanic margins such as western Central and South America?
- What are the geological and geochemical processes that modify sedimentary material to form hydrocarbon and mineral resources?
- What role do the polar regions play in global weather and climate?
- How can "gene-splicing" techniques be used to better understand gene function resulting in improved crop production?
- What are the key relationships between the structure and dynamics of antarctic water masses and the biological processes leading to high productivity?

Science Education

- What learning processes are involved in understanding scientific and mathematical concepts at various educational levels?
- What are the most effective mechanisms for increasing participation of minorities, women, and the handicapped in scientific careers?
- What techniques and approaches can be employed to provide scientific and technical expertise to citizens to increase their ability to make wise choices on technical public policy issues?
- What new instructional materials, educational practices, and research findings are essential for improving science education, especially for the early adolescent?
- How can we most effectively apply technology to the teaching and learning of mathematics and science?
- How can we increase our understanding of the relationship between learning processes and the nature and structure of scientific and mathematical knowledge?

Engineering and Applied Science

- How can techniques of microfabrication be improved and what kinds of new microstructures can be made with these improved techniques?
- What opportunities are there for the use of man-made microstructures such as sensors, transducers, information, processing systems, and microprosthetic systems?
- How can understanding of physical interactions on catalytic surfaces lead to the design of more efficient catalysts for industrial processes, including synthetic fuel production?
- How can the strength of fiber reinforced structural materials, including that of concrete, be improved?

- How can recent developments in computer technology best be applied to automated manufacturing processes, with particular reference to robotics?
- How do national fiscal, monetary and regulatory policies affect the costs and management of programs by State and local governments?
- What new processes and technologies can be developed for improving the efficiency of separation of minerals from low grade ore bodies and the handling of the resulting processing wastes?
- How can the design of structures, dams, and other vital facilities provide effective earthquake protection at acceptable cost, and what are the social factors involved in mitigating earthquake hazards and disasters?

Scientific, Technological, and International Affairs

- What are the economic effects of tax policy on R&D and technological innovation? Of government R&D funding? Of regulations?
- How adequate are the estimates of risks associated with different technologies?
- What is the impact of rising costs on the Nation's R&D activities?
- What are the abilities and limitations of people transferring information to and from physical subsystems such as computer terminals?
- What relationships exist between information and the structure of language?
- How can R&D be better utilized to assist lesser developed countries in pursuing their domestic, social, and economic policy objectives?

SNAPSHOTS OF ITEMS IN THE FY 1981 NSF BUDGET

Mathematical and Physical Sciences

- Research project support in Mathematics, Physics, Chemistry, and Materials ($174.7 million)—Includes increased funding to allow for more adequate project support levels.
- Experimental computer research ($3.7 million)—Provides support for enhancing the experimental computer research capability at universities, including modern computing systems, together with associated development, maintenance, and operating costs.
- Research related to microstructures in Chemistry, Materials Research, and Computer Research ($9.0 million)—Funding for this research increases by $2.0 million above the FY 1980 level of $7.0 million.
- Cornell Electron Storage Ring (CESR) ($7.4 million)—Provides for operations and research costs for the newly converted positron—electron colliding beam facility.
- Research instrumentation and equipment ($42.4 million)—Includes more adequate instrumentation and equipment for research projects, special equipment programs, university laboratories, and major user facilities.
- Materials Research Laboratories ($22.2 million)—Strengthens interdisciplinary research in key areas, permits some upgrading of experimental facilities, and provides more viable support at the smaller laboratories.

Astronomical, Atmospheric, Earth and Ocean Sciences

- Very Large Array (VLA) for Radio Astronomy ($3.2 million)—$4.3 million decrease resulting from completion of funding for VLA fabrication in FY 1980 is partly offset by a $1,850,000 increase in the first year of full VLA operations.
- New 25 meter diameter, millimeter wave telescope ($1.7 million)—This provides support for detailed design and specifications. This action carries with it a commitment to go ahead with the construction of the telescope during FY 1982—FY 1984 at a total cost in current dollars estimated to be approximately $27.0 million.
- Climate Research ($6 million)—Continuation of Climate Dynamics research.
- Coordinated Research and Exploration ($23,600,000). Succeeds the International Decade of Ocean Exploration which ends in FY 1980.
- Earthquake Research ($1.2 million)—Continuation of basic earth sciences research related to the occurrence, location and severity of earthquakes.
- Coastal Research Ships ($3.8 million)—Construction of one 130-140 ft. ship.

- Instrumentation and Equipment ($26.7 million)—Includes $6.6 million for major equipment, including the research ship; and $20.1 million for other research equipment for use on research projects and at national centers.

U.S. Antarctic Program

- Repairs to Aircraft ($2 million)—Includes repairs to a crash-damaged LC-130 aircraft and for modifications to extend the present service life of an older LC-130 aircraft.

Ocean Drilling Programs

- Ocean Margin Drilling Project ($10 million)—These funds together with matching funds from the petroleum industry will take the project up to the point of modifications to the U.S. owned research ship, the *Glomar Explorer*, drilling system procurement, and drilling site selection. This initial effort will provide a basis for the final go, no-go decision for the project as a joint venture between industry and in the government.

Biological, Behavioral and Social Sciences

- Genetic Biology ($10.3 million)—Research support for studies of genetics of plants, gene-splicing in plants and animals, and the transmission and regulation of hereditary material.
- Research Instrumentation ($16.1 million)—This total is included generally as a part of research grants and provides for enhancement of the accessibility and sharing of improved equipment for researchers in the biological, behavioral and social sciences.
- Neurosciences ($17.0 million)—Research support for studies focused on understanding the action, mechanisms and functions of nerve cells and sensory receptors.
- Cognitive Science ($5.6 million)—Research support for studies on the mental representation of knowledge, the development of cognitive capacities, and the acquisition of language, human learning and thought.
- Anthropology ($7.6 million)—Research support for studies centering on tracing the course of human evolution over several million years and to examine the effects of nutritional and demographic factors on societal evolution.
- Ecosystems ($13.0 million)—Support for research addressing critical problems involving ecosystems management such as global carbon dioxide and acid rain.
- Economics, Geography, and Political Science ($15.8 million)—Support of research studies to expand the scientific understanding of the processes underlying the performance of the economy.

Engineering and Applied Science

- Computer Engineering ($2.2 million)—Research efforts in computer vision and applications, as well as robotics, related to productivity enhancement in the U.S.

- Microstructures Engineering ($4.7 million)—Supports the Submicron Resource Facility at Cornell University and provides for resarch on ionbeam-based microfabrication techniques and composite materials systems for electronic devices.
- Earthquake Hazards Mitigation ($19.4 million)—Research on the effectiveness of regulations to achieve given levels of earthquake protection and on the impact of earthquake warning and prediction measures on the socioeconomic environment of the community.
- State Science, Engineering, and Technology ($3.0 million)—Supports efforts designed to build the capacity of states to assess and use scientific and technical information in the public policy development process.
- Small Business Innovation ($13.0 million)—Provides an opportunity and an incentive for small science and technology-based firms to undertake high risk research in connection with research programs that also could have significant benefit to the industrial economy.
- Industrial Technology ($5.2 million)—Supports research on experimental incentives designed to increase the commitment of U.S. industry to research and development and to provide long-term bridges between industry and universities in selected generic technologies.

Scientific, Technological and International Affairs

- West Europe Program ($1.8 million)—Expansion of cooperative research thrust in Western Europe where scientific and technical capabilities in some fields rival or surpass those in the U.S. and where U.S. scientists can most benefit from cooperation.
- Science in Developing Countries ($1.1 million)—Support of research and teaching that relate the application of science and engineering to problems of development in Asia, Africa, Latin American, and the Caribbean.
- Technology Assessment and Risk Analysis ($1.4 million)—Expansion of the risk analysis function to improve methods for evaluating long-term comparative risks and benefits of alternative technologies.
- International Economic Policy ($750,000)—A new focused research and analysis program on issues of international economic policy affecting domestic economic progress and the conduct of foreign relations.
- Postcensal Survey of U.S. Scientists and Engineers ($500,000)—Continued design and planning of a key survey of scientists and engineers to be identified in the 1980 Decennial Census.
- Information Technology ($400,000)—A new program to assess emerging information systems and to design more effective instrumentation for information science research in areas not supported within the private sector.

Cross-Directorate Programs

- Industry/University Cooperative Research ($20.0 million). Strengthens research ties between two major components of the Nation's scientific and technological systems. Research is focused on fundamental scientific or engineering issues of a basic or applied nature.
- Instrumentation and Facilities ($20.25 million). Provides increased support for instrumentation and facilities for 2-year and 4-year colleges; for universities with outmoded graduate-level facilities; and for improving geographic distribution of specialized instrumentation across the Nation.
- U.S./China Cooperation in Basic Sciences ($2.0 million). Provides for cooperation with Chinese scientists in a broad research program in the basic biological, social, mathematical, and physical sciences.
- Decision and Management Sciences ($1.0 million). Increases the scientific base and knowledge leading to the improvement of organizational decisions, management, and operations of public and private enterprises.

Science Education

- Science Education for The Early Adolescent ($14.0 million)—Focuses continued effort at a point of high opportunity—the junior high/middle school years. We need to know more about why many of this age group—particularly minorities and girls—choose not to study science and mathematics beyond this age and thus preclude themselves from possible preparation for future science and technology-related careers.
- Research in Science Education ($6.5 million)—Supports studies to gain knowledge needed to identify and develop the processes by which science is learned and to understand the motivational factors involved in pursuing science as a career. The motivational aspects of learning in the current decade are expected to play an important role in the development of the cadre of scientists of the future.
- Public Understanding of Science ($5.0 million)—Supports efforts to improve the understanding of science by all citizens and to make information available to nonspecialists in order to increase their basic understanding of science and its contribution to the quality of life. The ability of science and technology to contribute to the national welfare depends not only on the inventiveness and technical competence of its practitioners but also on the degree to which its results are understood by citizens and can be assimilated into our social structures and institutions.
- College Science Teaching ($4.0 million)—Provides for subject-matter revitalization of college science teaching. The quality and currentness of college science teaching have been declining as a result of a series of events, among which are: reduced enrollments, declining birth rates, reduced mobility of faculty, changing composition of the student body and changing job market. Because of these factors, the Foundation is proposing to give priority, as a new major thrust in FY 1981, to the updating of the subject-matter competence of college science faculty.

RESEARCH FACILITIES, EQUIPMENT, AND INSTRUMENTATION

The Foundation provides support for a variety of research facilities, major equipment, and other equipment and instrumentation that are essential to the performance of advanced scientific research. NSF support is summarized in the following table and discussed in the paragraphs below.

RESEARCH FACILITIES AND EQUIPMENT
Budget Authority/Obligations in Millions of Dollars

Fiscal Year and Activity	*Land, Buildings, and Fixed Equipment*	*Major Equipment*	*Other Equipment and Instrumentation*	*Total*
FY 1979				
Mathematical and Physical Sciences	—0—	$11.2	$28.0	$39.2
Astronomical, Atmospheric, Earth and Ocean Sciences	4.9	10.9	16.2	32.0
U.S. Antarctic Program	2.5	—0—	5.7	8.2
Biological, Behavioral, and Social Sciences	—0—	—0—	17.1	17.1
Engineering and Applied Science	—0—	0.7	11.3	12.0
Total, FY 1979	7.4	22.8	78.3	108.5
FY 1980				
Mathematical and Physical Sciences	—0—	6.4	30.4	36.8
Astronomical, Atmospheric, Earth and Ocean Sciences	1.7	7.1	17.5	26.3
U.S. Antarctic Program	2.6	1.0	5.0	8.6
Biological, Behavioral, and Social Sciences	—0—	—0—	14.6	14.6
Engineering and Applied Science	—0—	0.5	12.0	12.5
Cross-Directorate Programs	—0—	—0—	5.7	5.7
Total, FY 1980	4.3	15.0	85.2	104.5
FY 1981				
Mathematical and Physical Sciences	—0—	6.5	35.9	42.4
Astronomical, Atmospheric, Earth and Ocean Sciences	0.1	4.8	21.8	26.7
U.S. Antarctic Program	3.2	1.6	4.5	9.3
Ocean Drilling Program	—0—	—0—	1.0	1.0
Biological, Behavioral, and Social Sciences	—0—	—0—	16.1	16.1
Engineering and Applied Science	—0—	0.7	13.1	13.8
Cross-Directorate Programs	14.3	—0—	2.9	17.2
Total, FY 1981	17.6	13.6	95.3	126.5
Difference—FY 1981/FY 1980	13.3	-1.4	10.1	22.0

Definitions

Definitions of the various categories of non-expendable research items supported by NSF are as follows:

- *Land, Buildings, and Fixed Equipment*—Acquisition, construction, rehabilitation, addition to, or improvement of real property assets, such as land, buildings or other structures, and fixed equipment. "Fixed equipment" means equipment that is part of the building, such as elevators, plumbing, lighting and heating systems, air conditioning systems, fire alarm systems, and the like.

NSF normally supports the construction of buildings only at the National Research Centers and in Antarctica but occasionally provides support for buildings needed to house a major equipment item such as an accelerator.

- *Major Equipment*—Applies to a relatively limited number of specific items of specialized R&D equipment, such as accelerators, telescopes, research ships, aircraft, and the like.
- *Other Equipment and Instrumentation*—Includes all R&D equipment *other than* those items specifically categorized as "Major Equipment." To qualify as equipment, an item must cost at least $300 and have a use-life of at least one year.

Detection, measurement and the handling of data are important steps in many research activities. Many fields of science such as chemistry, physics and astronomy are extremely instrument-intensive, and others such as the biosciences are becoming more so. Sophisticated, complex instrumentation is a prerequisite to research on forefront topics.

Facilities, Equipment, and Instrumentation Funding

Support for research facilities and equipment increases from $104.5 million in FY 1980 to $126.5 million in FY 1981 or by 21.1 percent. A substantial part of this increase, $14.25 million, will be used on a one-to-one matching basis to upgrade university laboratories. Support is also provided for special instrumentation and equipment programs, including the 2-year and 4-year College Instrumentation Program ($3.0 million) and the Regional Instrumentation Facilities Program ($3.0 million—$2.8 million for operational costs and $0.2 million for equipment).

BUDGET SUMMARY OF OBLIGATIONS BY ACTIVITY AND SUBACTIVITY SHOWING DOLLAR AND PERCENTAGE CHANGES, FY 1981/FY 1980

(Millions of Dollars)

Activity & Summary	*FY 1979*	*FY 1980 Current Plan*	*FY 1981 Budget Request*	*Difference FY 1981/FY 1980*	
				Amount	*Percent*
RESEARCH & RELATED ACTIVITIES APPROPRIATION					
Mathematical and Physical Sciences					
Mathematical Sciences	27.8	24.9	29.3	4.4	17.7
Computer Research	16.8	18.2	23.3	5.1	28.1
Physics	61.7	63.4	73.5	10.1	16.0
Chemistry	45.2	51.4	59.5	8.1	15.7
Materials Research	62.4	68.5	78.6	10.1	14.7
Subtotal, MPS	208.9	226.4	264.2	37.8	16.7
Astronomical, Atmospheric, Earth and Ocean Sciences					
Astronomical Sciences	59.2	57.0	60.2	3.2	5.7
Atmospheric Sciences	59.1	63.2	71.1	7.9	12.6
Earth Sciences	24.9	25.3	27.9	2.6	10.4
Ocean Sciences	62.4	66.6	76.0	9.4	14.1
Arctic Research	6.0	5.8	6.1	.3	4.6
Subtotal, AAEO	211.6	217.9	241.3	23.4	10.8
U.S. Antarctic Program					
U.S. Antarctic Research Program	7.3	8.0	9.3	1.3	16.2
Operations Support	43.8	47.8	54.1	6.3	13.1
Subtotal, USAP	51.1	55.8	63.4	7.6	13.5
Ocean Drilling Program					
Ocean Sediment Coring Program	10.6	15.9	17.3	1.4	9.0
Ocean Margin Drilling Program	1.0	3.6	10.0	6.4	177.8
Subtotal, ODP	11.6	19.5	27.3	7.8	40.2
Biological, Behavioral, and Social Sciences					
Physiology, Cellular & Molecular Biology	62.3	67.2	74.8	7.6	11.3
Behavioral & Neural Sciences	33.1	35.4	38.7	3.3	9.2
Social & Economic Science	25.4	26.2	27.8	1.6	6.1
Environmental Biology	33.9	37.7	40.7	3.0	8.1
Subtotal, BBS	154.7	166.5	182.0	15.5	9.3
Engineering and Applied Science					
Engineering:					
Electrical, Computer & Systems Engineering	17.0	17.6	22.5	4.9	27.8
Chemical & Process Engineering	13.0	13.9	16.7	2.8	20.0
Civil & Environmental Engineering	8.2	9.3	10.1	.8	8.9
Mechanical Sciences & Engineering	10.7	11.7	13.3	1.6	14.2
Subtotal, Engineering	48.9	52.5	62.6	10.1	19.3
Applied Sciences:					
Applied Research	17.6	17.6	18.7	1.1	6.1
Problem-Focused Research	32.6	28.9	30.5	1.6	5.6
Intergovernmental Science	5.1	5.5	7.0	1.5	27.3
Small Business Innovation and Industrial Technology	5.7	7.3	18.2	10.9	146.9
Subtotal, Applied Science	61.0	59.3	74.4	15.1	25.3
Subtotal, EAS	109.9	111.8	137.0	25.2	22.5

BUDGET SUMMARY OF OBLIGATIONS BY ACTIVITY AND SUBACTIVITY SHOWING DOLLAR AND PERCENTAGE CHANGES, FY 1981/FY 1980—Continued

(Millions of Dollars)

Activity & Summary	*FY 1979*	*FY 1980 Current Plan*	*FY 1981 Budget Request*	*Difference FY 1981/FY 1980*	
				Amount	*Percent*[1]
Scientific, Technological, and International Affairs					
International Cooperative Science Activities	10.6	12.0	12.9	.9	7.4
Policy Research & Analysis	5.5	5.7	6.6	.9	15.7
Science Resources Studies	3.1	3.2	3.4	.2	6.6
Information Science & Technology	4.4	5.2	5.9	.7	14.5
Subtotal, STIA	23.6	26.1	28.8	2.7	10.5
Cross-Directorate Programs					
Industry/University Cooperative Research	5.4	7.0	20.0	13.0	183.7
Special Facilities & Instrumentation:					
University Research Facilities Improvement	—0—	—0—	14.3	14.3	—0—
2-Year/4-Year College Instrumentation	.6	3.3	3.0	-.3	-9.1
Regional Instrumentation Facilities	5.0	4.8	3.0	-1.8	-37.5
Subtotal, Special Facilities & Instrumentation	5.6	8.1	20.3	12.2	150.0
Cross-Directorate International Programs:					
U.S./U.S.S.R. Cooperative Research Program	3.4	3.2	3.2	—0—	—0—
U.S./China Cooperation in Basic Sciences	—0—	1.0	2.0	1.0	100.0
Subtotal, Cross-Directorate International Programs	3.4	4.2	5.2	1.0	23.8
Other Programs:					
Research Initiation in Minority Institutions	.4	1.0	1.0	—0—	—0—
Experimental Program to Stimulate Competitive Research	.9	3.9	2.7	-1.2	29.9
Post-Doctoral Fellowships	[2](1.8)	(.9)	(.9)	.9	—0—
Decision and Management Sciences	—0—	—0—	1.0	1.0	—0—
Waterman Award	.1	.1	.1	—0—	—0—
NSF Planning and Evaluation	1.0	1.2	.8	-.4	-36.2
Subtotal, Other Programs	2.4	6.2	6.5	.3	5.3
Subtotal, Cross-Directorate Programs	16.8	25.5	52.0	26.5	103.5
Program Development and Management	54.7	60.6	60.8	.2	.4
Subtotal, Research & Related Activities	842.9	910.1	1,056.8	146.7	16.1
Science Education Activities Appropriation					
Scientific Personnel Improvement	33.1	31.6	35.2	3.6	11.4
Science Education Resources Improvement	28.6	24.0	24.2	.2	.8
Science Education Development & Research	12.0	14.9	17.5	2.6	17.1
Science and Society	6.3	7.7	8.8	1.1	15.0
Subtotal, Science Education Activities	80.0	78.2	85.7	7.5	9.6
Subtotal, Dollar Activities	922.9	988.3	1,142.5	154.2	15.6
Special Foreign Currency Appropriation	4.0	5.5	5.5	—0—	—0—
Total, NSF	926.9	993.8	1,148.0	154.2	15.5

[1] Percentages based on unrounded tabular amounts.

[2] Post-Doctoral Fellowships included in Science Education Activities prior to FY 1981.

MATHEMATICAL AND PHYSICAL SCIENCES

FY 1981 PROGRAM TOTAL $264,200,000

Obligations by Subactivity

Subactivity	Actual FY 1979	Budget Request FY 1980	Current Plan FY 1980	Estimate FY 1981	Difference FY 1981/80
Mathematical Sciences	$22,782,576	$25,400,000	$24,901,000	$29,300,000	$4,399,000
Computer Research	16,771,026	18,600,000	18,235,000	23,350,000	5,115,000
Physics	61,664,569	64,300,000	63,361,000	73,500,000	10,139,0000
Chemistry	45,230,481	52,935,000	51,414,000	59,500,000	8,086,000
Materials Research	62,416,265	69,000,000	68,501,000	78,550,000	10,049,000
Total	$208,864,917	$230,235,000	$226,412,000	$264,200,000	$37,788,000

Goals and Description

The goal of the Mathematical and Physical Sciences (MPS) activity is to develop a fundamental understanding of the physical laws that govern the world and the universe in which we live. To further this goal, basic research activities are supported in the disciplines of mathematics, computer science, physics, chemistry, and materials. Research results in these fields provide the underlying knowledge for the future technological developments upon which our economic and social well being so intimately depend. They also form much of the intellectual underpinning for engineering and the biological, environmental, and behavioral sciences, as well as provide many of the research instruments and techniques necessary to progress in these fields. More specifically, the Mathematical and Physical Sciences activity strengthens the Nation's research capability by:

- Creating new mathematical knowledge and applying that knowledge to achieve a better understanding of physical, biological, and social phenomena.
- Developing an understanding of the science that underlies computer technology and formulating the principles of design of computer hardware and software systems.
- Advancing knowledge of the fundamental physical laws governing matter and energy with the ultimate goal of achieving a unified, self-consistent explanation of all physical phenomena.
- Stimulating the development of modern chemistry on a broad front, including chemical synthesis, analysis, dynamics, structure, and theory.
- Developing an improved understanding of the fundamental principles, phenomena, and concepts that govern the physical, chemical, and mechanical properties of materials.

With the development of powerful new theoretical concepts, incisive experimental approaches, and sophisticated modern instruments of unprecedented power, resolution, and sensitivity, the MPS disciplines are currently in a period of unusual activity and opportunity. The richness of modern mathematical research, the challenge of complexity in computer science, and progress in understanding the fundamental forces and constituents of matter illustrate the diversity of this opportunity. The revolution in laser-related research, the intense activity in surface science and catalysis research, the power of modern synthetic chemistry, and the unique properties of new amorphous and polymeric materials all suggest the potential to serve the future needs of society as well. Overall, MPS ensures that the most highly qualified investigators across the broad range of disciplines are provided with the resources required to carry out their research, including the necessary instrumentation. To provide these resources MPS utilizes a wide range of support modes, from individual research projects through departmental or university laboratories to regional or national research facilities.

FY 1981 Budget Highlights and Explanation of Increases and Decreases

Obligations

FY 1979 Actual	$208,864,917
FY 1980 Program	$226,412,000
FY 1981 Request	$264,200,000
Difference—FY 1981/FY 1980	$37,788,000

The $264.2 million requested for Mathematical and Physical Sciences (MPS) is 16.7 percent above the FY 1980 program level. Even taking into account the anticipated increased costs of performing research, this increase represents significant real growth. NSF has a unique responsibility for ensuring the health and vitality of the Nation's research across each of the component disciplines, although careful consideration is given to trends in research funding by other Federal agencies in determining program requirements. Detailed analysis of these program requirements in connection with long range planning activities has established that overall Federal support for research in the MPS disciplines has eroded to the point where adequate funding is no longer available to provide the most highly qualified investigators with the resources required to carry out their research in an optimum manner.

The FY 1981 Budget Request emphasizes augmented research project support for all disciplines, including provision of modern research instrumentation. In general, this emphasis is directed at achieving real growth in average award size in order to provide more adequate support, including that to young investigators, for graduate students, postdoctoral fellows, equipment, and materials and supplies. At the same time, provision is made for meeting the essential requirements of the university laboratories, such as the Materials Research Laboratories and the Nuclear Science Laboratories, and of major user facilities such as the Cornell Electron Storage Ring, the Synchrotron Radiation Facilities, and the National Magnet Laboratory. These laboratories and facilities represent an effective, and often the only, mode for carrying out certain types of research. The request also includes a special emphasis on improving the Nation's academic research capability in experimental computer science. Computer research has become primarily a theoretical science in U.S. universities, and the emergence of modern integrated circuit technology presents both the opportunity and the means for making posssible major experimental contributions to this important and growing field. Throughout, the FY 1981 budget request provides for increased flexibility to undertake, on a selective basis, new initiatives particularly suited to MPS capabilities, and to respond more positively to proposals in areas of expanding scientific opportunity.

The distribution of the FY 1981 budget amounts for the five MPS subactivities is based on an extensive analysis of research needs and opportunities. Percentage changes are as follows:

Mathematical Sciences	17.7%
Computer Research	28.1%
Physics	16.0%
Chemistry	15.7%
Materials Researach	14.7%

Explanation of Increases, Decreases, and Continuing Emphases

Research Project Support and Instrumentation—In the Mathematics, Physics, Chemistry, and Materials Research subactivities, research project support is increased by $25.2 million to a total of $174.7 million. Included in that amount is project instrumentation and equipment, as well as Chemistry departmental equipment. Because of the unique requirements of Computer Research, that subactivity is considered separately below.

- Significant real growth in average award size is achieved, particularly in Physics, Chemistry, and Materials Research.
- The postdoctoral program in Mathematics is continued at a level of $0.6 million, and a modest program for young investigators is initiated in Physics at a level of $0.3 million. The young investigator question is addressed in all disciplines, however, primarily by provision of more adequate research support.
- Research related to microstructures in Chemistry and Materials Research is increased by $1.8 million to a total of $7.7 million.
- Emphasis continues in areas of expanding scientific opportunity such as laser-related research, elementary particle and gravitational physics, organometallic chemistry, surface science and catalysis, and unique new materials.
- Within this total, research project instrumentation, including departmental equipment in Chemistry, is increased by $5.0 million to a total of $26.2 million.

University Laboratories—Support for University Laboratories in Physics and Materials Research is increased by $3.9 million to a total of $36.1 million.

- The research capabilities of the intermediate energy electron accelerators at

Illinois and Stanford are enhanced by increasing their support by $0.8 million to a total of $4.6 million.

- Instrumentation and operating support are maintained at the other university nuclear science laboratories by the phase out of one laboratory, a significant reduction in NSF support of another, and an additional increase in funding of $0.3 million to a total of $9.2 million for the remaining laboratories.
- Support for the Materials Research Laboratories is increased by $2.8 million, to a total of $22.2 million. This increase strengthens cooperative research in key areas, permits some upgrading of experimental facilities, including instrumentation, and provides for more viable support levels at the smaller laboratories.

National User Facilities—Support for national user facilities in Mathematics, Physics, Chemistry, and Materials Research is increased by $3.4 million, to a total of $29.9 million.

- Support for a mathematical sciences research institute and/or other alternative modes of conducting mathematics research is increased by $0.8 million to a total of $1.4 million.
- Increases to offset the increased costs of performing research are provided for the newly converted Cornell Electron Storage Ring, the Indiana University Cyclotron Facility, and the Michigan State University Phase I heavy ion accelerator, thus ensuring effective levels of operation.
- An increase of $0.6 million provided for the Institute for Theoretical Physics as it enters its first full year of operation at the planned level of $1.2 million.
- Funding for the synchrotron radiation facilities at Stanford and Wisconsin is held essentially constant as construction activities are completed and increased levels of operation and instrumentation are implemented. Support for half-time dedicated operation of the accelerator at Stanford (SPEAR) continues at a level of $2.0 million.
- A modest increase in the current level of effort at the National Magnet Laboratory is utilized to provide for magnet development and instrumentation.

Computer Research—An increase of $5.1 million is provided for Computer Research, bringing the total support for that subactivity to $23.35 million. This level of support permits significantly increased emphasis on establishing a meaningful experimental computer research capability in U.S. universities.

- Longer range support for experimental computer research is increased by $2.7 million to a total of $3.7 million. Although dependent on the nature and quality of proposals received, it is anticipated that this support will provide for modern computing facilities, together with associated development, maintenance, and operating costs.
- In order to permit effective sharing of resources among dispersed research groups, $0.75 million is provided to develop a nationwide computer research network designed during FY 1980.

- A national competition for awards to young investigators in experimental computer science is initiated at a level of $0.9 million.
- Support for microstructures-related computer research is increased by $0.2 million to a total of $1.3 million.

Research Instrumentation and Equipment—Included above is support for instrumentation and equipment for research projects, special equipment programs, university laboratories, and major user facilities, which is increased by $5.5 million to a total of $42.4 million. Of this amount, some $1.0 million is for non-recurring instrumentation requirements, compared to $3.0 million in FY 1980.

ASTRONOMICAL, ATMOSPHERIC, EARTH, AND OCEAN SCIENCES

FY 1981 PROGRAM TOTAL $241,300,000

Obligations by Subactivity

Subactivity	Actual FY 1979	Budget Request FY 1980	Current Plan FY 1980	Estimate FY 1981	Difference FY 1981-'80
Astronomical Sciences	$59,221,107	$58,550,000	$56,964,000	$60,200,000	$3,236,000
Atmospheric Sciences	59,106,778	65,750,000	63,169,000	71,100,000	7,931,000
Earth Sciences[1]	24,919,404	26,250,000	25,278,000	27,900,000	2,622,000
Ocean Sciences	62,393,725	68,450,000	66,619,000	76,000,000	9,381,000
Arctic Research Program	5,974,000	6,000,000	5,832,000	6,100,000	268,000
Total	$211,615,014	$225,000,000	$217,862,000	$241,300,000	$23,438,000

[1] The Ocean Sediment Coring Program has been moved from the AAEOS Activity to Ocean Drilling Programs, a separate activity.

Goals and Description

The Astronomical, Atmospheric, Earth, and Ocean Sciences Activity supports basic research in selected disciplines that will increase our knowledge of the natural environment on earth and in space. The overall objectives of the various elements comprising the activity are as follows:

- Obtain new knowledge of astronomy and the atmospheric sciences over the entire spectrum of physical phenomena;
- Provide a better understanding of the physical and chemical make-up of the earth and its geological history;
- Obtain further insights into the oceans' composition, structure, behavior, and resources, and examine the effect of human activities on the ocean environment and vice versa;
- Advance knowledge of natural phenomena and processes in the Arctic.

The objectives are pursued through the following subactivities:

Astronomical Sciences. Support of basic research projects and national research facilities is directed at examining the physical principles governing the universe as well as the properties and behavior of its objects. The latter include planets and their atmospheres, our sun, other stars, the Milky Way galaxy, and remote galaxies and quasars.

Atmospheric Sciences: Support is provided for basic research projects and for the National Center for Atmospheric Research to facilitate our understanding of the behavior of the earth's atmosphere.

Earth Sciences: The programs under Earth Sciences are designed to increase our basic knowledge of the solid earth and its evolution. Emphasis is placed on chemical and physical characteristics and processes that produce geologic features including hydrocarbon and ore deposits and events such as earthquakes.

Ocean Sciences: The activities supported are geared to improve understanding of the nature of the ocean, of its influence on human activities, and of society's impact on the marine environment. This is accomplished through Oceanography Project Support, Coordinated Ocean Research and Exploration, and support for oceanographic facilities essential to the research efforts.

Arctic Research Program: Research is supported in the disciplines of geology and geophysics, biology, oceanography, meteorology, glaciology, and upper atmospheric physics. Among the studies underway are those on permafrost, deep ice cores from Greenland, arctic lake and tundra ecosystems, and the resources of the Bering Sea Shelf.

FY 1981 Budget Highlights and Explanation of Increases and Decreases

Obligations

FY 1979 Actual	$211,615,014
FY 1980 Program	$217,862,000
FY 1981 Request	$241,300,000
Difference—FY 1981/FY 1980	$23,438,000

Major program or project changes in FY 1981 include:

- In Astronomical Sciences a $4,500,000 decrease resulting from completion of funding for Very Large Array fabrication in FY 1980 is largely offset by a $1,850,000 increase for the first year of full VLA operations (total $5,200,000), and detailed design and specifications for a new 25 meter diameter, millimeter wave telescope at $1,700,000. The 25 meter telescope will require an additional $27,000,000 in Fiscal Years 1982-1984.
- An additional $2,826,000 for the astronomy centers will help meet increased operating cost ($1,523,000) and provide instrumentation ($1,303,000). Totals in these categories are operations $30,852,000 and instrumentation $3,228,000.
- An increase of $1,360,000 in Astronomy project support to $19,220,000 will help meet increased costs.
- In Atmospheric Sciences an increase of $4,331,000 in project support to $38,600,000 will expand atmospheric chemical research, climate modeling and cloud physics, continue Global Atmospheric Research Program (GARP) projects and begin data analysis of previous GARP field experiments and an observational program of the Solar Maximum Year. Upgrading of a radar network for upper atmospheric observations and new observing tools to study mesoscale meteorological processes are also included.

- An increase of $3,300,000 to $29,900,000 for the National Center for Atmospheric Research provides for continued support of studies in solar variability, trace gases and aerosols, modeling and convective storm processes, and of aircraft and the Cray-1 computer. Administrative services costs are increased.
- A $300,000 increase to $2,600,000 for the National Scientific Balloon Facility will help continue support services to ongoing programs, renovate the former operations building and begin procurement of equipment for Long Duration Ballooning experiments.
- In Earth Sciences, an increase of $2,622,000 to $27,900,000 will allow for increased emphasis on geologic research on the U.S. continental crust and continued support of the Consortium on Continental Reflection Profiling, lunar sample analysis, research on the nature of earthquakes, modern geological processes, ore-forming fluids and ore deposits, and some instrumentation in geochemistry and geophysics.
- An increase of $3,250,000 to $24,600,000 in Oceanography Project Support will maintain the diversity of current programs, as well as increase emphasis on open-ocean dynamics using new tools such as satellite imagery and chemical tracers, all aspects of recently discovered sea floor hydrothermal vents, paleo-oceanography, and primary productivity and food chain processes in the open ocean.
- The Coordinated Ocean Research and Exploration program element increases by $2,850,000 to $23,600,000 includes initiation of projects in ocean acoustic tomography, the impact of rivers on the ocean, and studies of ecosystem production and control mechanisms. This increase will also expand meteorological support for the Sea-Air Exchange project, study of the effect of Western boundary current eddies on the continental shelf and research, particularly chemical, on the hydrothermal circulation of seawater through the oceanic crust.
- A $3,281,000 increase in Oceanographic Facilities and Support to $27,800,000 is necessary to maintain adequate logistics support for the research components of Ocean Sciences. Technician support and ship board equipment are increased along with operations support. The construction/conversion budget includes $3,600,000 for a new coastal research ship to continue the planned upgrading of the academic fleet to increase its efficiency and meet research needs.
- Arctic research increases by $268,000 to $6,100,000 and will continue to provide support for biological research on the Bering Sea Shelf, and geological and geophysical research in Alaska and elsewhere in the arctic.

U.S. ANTARCTIC PROGRAM

FY 1981 PROGRAM TOTAL $63,400,000

Obligations by Subactivity

Subactivity	Actual FY 1979	Budget Request FY 1980	Current Plan FY 1980	Estimate FY 1981	Difference FY 1981-80
U.S. Antarctic Research Program	$ 7,281,809	$ 8,000,000	$ 8,000,000	[1]$ 9,300,000	$1,300,000
Operations Support Program	43,809,044	47,000,000	[3]47,840,000	[2]54,100,000	6,260,000
Total	$51,090,853	$55,000,000	$55,840,000	$63,400,000	$7,560,000

[1] These funds will support scientific activities in Antarctica during the October 1981 to March 1982 austral summer field season.

[2] These funds will provide support for the research activities to be conducted in Antarctica during the October 1980 to March 1981 austral summer field season.

[3] Includes $840,000 supplemental appropriation request for FY 1980 costs of October 1, 1979, military pay increase.

Goals and Description

The U.S. Antarctic Program supports national goals to: maintain the Antarctic Treaty, insure that the continent will continue to be used for peaceful purposes only, foster cooperative research to contribute to the solution of regional and worldwide problems, protect the environment, and insure equitable and wise use of living and nonliving resources.

The U.S. scientific research program in Antarctica continues to be the principal expression of national interest and policy. The goal of the U.S. Antarctic Research Program is the scientific investigation of Antarctica and the surrounding oceans. Objectives are to develop an understanding of the role played by the antarctic ice sheets and the antarctic physical, biological, geological, meteorological, atmospheric, chemical and oceanographic processes.

The antarctic area is of further interest to the United States because it:

- Has a major influence on world weather and climate,
- Has the world's richest marine protein resource potential,
- Has other features of unique scientific and practical interest, and
- Provides an excellent environment for international cooperation.

The National Science Foundation has been assigned overall management responsibility for planning, funding, and implementing the national program in Antarctica.

- An increase of $3,300,000 to $29,900,000 for the National Center for Atmospheric Research provides for continued support of studies in solar variability, trace gases and aerosols, modeling and convective storm processes, and of aircraft and the Cray-1 computer. Administrative services costs are increased.
- A $300,000 increase to $2,600,000 for the National Scientific Balloon Facility will help continue support services to ongoing programs, renovate the former operations building and begin procurement of equipment for Long Duration Ballooning experiments.
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- An increase of $3,250,000 to $24,600,000 in Oceanography Project Support will maintain the diversity of current programs, as well as increase emphasis on open-ocean dynamics using new tools such as satellite imagery and chemical tracers, all aspects of recently discovered sea floor hydrothermal vents, paleo-oceanography, and primary productivitiy and food chain processes in the open ocean.
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- Arctic research increases by $268,000 to $6,100,000 and will continue to provide support for biological research on the Bering Sea Shelf, and geological and geophysical research in Alaska and elsewhere in the arctic.

U.S. ANTARCTIC PROGRAM

FY 1981 PROGRAM TOTAL $63,400,000

Obligations by Subactivity

Subactivity	*Actual FY 1979*	*Budget Request FY 1980*	*Current Plan FY 1980*	*Estimate FY 1981*	*Difference FY 1981/80*
U.S. Antarctic Research Program	$ 7,281,809	$ 8,000,000	$ 8,000,000	[1]$ 9,300,000	$1,300,000
Operations Support Program	43,809,044	47,000,000	[3]47,840,000	[2]54,100,000	6,260,000
Total	$51,090,853	$55,000,000	$55,840,000	$63,400,000	$7,560,000

These funds will support scientific activities in Antarctica during the October 1981 to March 1982 austral summer field season.

These funds will provide support for the research activities to be conducted in Antarctica during the October 1980 to March 1981 stral summer field season.

Includes $840,000 supplemental appropriation request for FY 1980 costs of October 1, 1979, military pay increase.

Goals and Description

The U.S. Antarctic Program supports national goals to: maintain the Antarctic Treaty, insure that the continent will continue to be used for peaceful purposes only, foster cooperative research to contribute to the solution of regional and worldwide problems, protect the environment, and insure equitable and wise use of living and nonliving resources.

The U.S. scientific research program in Antarctica continues to be the principal expression of national interest and policy. The goal of the U.S. Antarctic Research Program is the scientific investigation of Antarctica and the surrounding oceans. Objectives are to develop an understanding of the role played by the antarctic ice sheets and the antarctic physical, biological, geological, meteorological, atmospheric, chemical and oceanographic processes.

The antarctic area is of further interest to the United States because it:

- Has a major influence on world weather and climate,
- Has the world's richest marine protein resource potential,
- Has other features of unique scientific and practical interest, and
- Provides an excellent environment for international cooperation.

The National Science Foundation has been assigned overall management responsibility for planning, funding, and implementing the national program in Antarctica.

The U.S. Antarctic Research Program subactivity supports a multidisciplinary research program on the Antarctic continent and in the adjacent oceans. The research is conducted at four antarctic stations, from remote temporary field sites, and aboard ships. Remote sensing techniques, using satellites, aircraft, rockets, balloons, and unmanned stations, are used in the conduct of the research. Cooperative research programs with scientists of other nations are commonplace.

The Operations Support Program subactivity provides for the direct support of science activities and the maintenance of an effective U.S. presence in Antarctica.

The National Science Foundation is designated as the single source of funding and management for the U.S. Antarctic Program. The Department of Defense and the Department of Transportation provide operational support as requested by NSF on a cost reimbursable basis. The Foundation also contracts for support services when it is cost effective.

FY 1981 Budget Highlights and Explanation of Increases and Decreases

Obligations

FY 1979 Actual	$51,090,833
FY 1980 Program	$55,840,000
FY 1981 Request	$63,400,000
Difference—FY 1981/FY 1980	$7,560,000

The $63,400,000 request for the U.S. Antarctic Program is $7,560,000 more than the FY 1980 program of $55,840,000.

The distribution of the FY 1981 budget amounts between the two budget subactivities and the percentage increases over FY 1980 are as follows:

U.S. Antarctic Research Program $9,300,000, up $1,300,000.
Operation Support Program $54,100,000, up $6,260,000.

The FY 1981 budget highlights are:

- Over one-half of the FY 1981 increase will be absorbed by inflation.
- Interdisciplinary research on the structure and function of the antarctic marine ecosystem will receive emphasis to provide information needed for the wise use and conservation of antarctic marine living resources.
- About forty percent of the operations support increase is for repairs to a crash-damaged LC-130 aircraft and for modifications to extend the present service life of an older LC-130 aircraft.
- The McMurdo Station physical facilities rehabilitation program will be accelerated.

OCEAN DRILLING PROGRAMS

FY 1981 PROGRAM TOTAL $27,300,000

Obligations by Subactivity

Subactivity	Actual FY 1979	Budget Request FY 1980	Current Plan FY 1980	Estimate FY 1981	Difference FY 1981/80
Deep Sea Drilling Project	$10,624,910	$15,400,000	$15,875,000	$17,300,000	$1,425,000
Ocean Margin Drilling Project:					
Project Planning and Evaluation	1,000,000	2,100,000	3,600,000	—0—	-3,600,000
Initial Implementation Phase	—0—	—0—	—0—	10,000,000	10,000,000
Total	$11,624,910	$17,500,000	$19,475,000	$27,300,000	$7,825,000

Goals and Description

The Ocean Drilling Programs (ODP) are a unique worldwide effort to explore the earth's crust beneath the oceans. An interdisciplinary science program aided by deep-ocean drilling and coring of rocks and sediments is aimed at understanding the detailed composition and behavior of the submerged 75 percent of the earth's surface that is of ever increasing importance to people and countries. These programs are aimed at:

- substantiating and refining the plate tectonics hypothesis that portrays the earth as a dynamic planet on which the distribution of continents and oceans changes continuously over geologic time. This will aid in a better understanding of the cause of violent natural processes, especially the volcanic activity and earthquakes that occur at crustal plate boundaries;
- utilizing detailed sediment records that document the paleoenvironment over many millions of years, and provide opportunities to explain the impact of the changing surface features of our planet on oceanic circulation and corresponding climate changes; and
- establishing the geological framework and studying the specific processes which cause the formation of natural resources and guide their distribution. Resource exploration builds on this scientific base.

The Ocean Drilling Programs activity includes two subactivities, the Deep Sea Drilling Project (DSDP) and the Ocean Margin Drilling Project (OMDP). The National Science Foundation has overall management responsibility for these programs.

The Deep Sea Drilling Project has been supported by NSF since FY 1966 and has been operating since FY 1968. DSDP operations are managed for NSF by the University of California/Scripps Institution of Oceanography (SIO). Under subcontract to SIO the drilling ship *Glomar Challenger* is operated by its owner Global Marine Inc. for DSDP. The scientific program for DSDP is guided by the Joint Oceanographic Institutions Inc. and their scientific advisory structure, the Joint Oceanographic Institutions for Deep Earth Sampling, which includes foreign members. The Deep Sea Drilling Project is now in the International Phase of Ocean Drilling to which five foreign countries, France, Germany, Japan, the U.K. and the U.S.S.R., each contribute $1,250,000 annually. DSDP/*Challenger* operations have been carried out in almost all of the world's oceans. Major contributions of DSDP are the first reconnaisance of the makeup of the earth's crust beneath the oceans and the most convincing research results to date in support of the plate tectonics hypothesis. Present NSF plans call for support of *Challenger* operations through FY 1981.

The Ocean Margin Drilling Project is a logical extension of DSDP. OMDP will attack the most important unresolved problems in the plate tectonics hypothesis as well as problems that have emerged from 11 years of Deep Sea Drilling Project efforts. The essential difference between OMDP and DSDP will be the transition from a general reconnaisance performed by DSDP to a problem-focused approach in OMDP. The major new initiative of OMDP will be an extensive investigation of the ocean margins. The passive margins with their thick sediment cover (e.g. the U.S. east coast) represent a major frontier for geologic exploration. Besides its great scientific importance, work on the deeply submerged ocean margins will constitute the first major effort to establish the geologic framework for determining the natural resource potential of these areas. The drilling system required for the ocean margin project greatly exceeds the capacity of the DSDP ship *Challenger*. The government-owned *Glomar Explorer* has been identified as an excellent candidate for the advanced drilling technology platform for OMDP.

In order to initiate the Ocean Margin Drilling Project a new approach has been taken. The U.S. petroleum industry has been invited to become a major partner and contributor in this project. Government/industry negotiations have proceeded to the point that a sufficient number of petroleum companies have indicated their willingness to participate and contribute during FY 1981. In that year engineering design and cost estimates for *Explorer* conversion, and the advanced deep-ocean drilling system as well as scientific program planning will proceed. Results of these efforts will provide the basis for a final go/no-go decision later in FY 1981 on the whole project as a joint venture.

Foreign participation in the Ocean Margin Drilling Program similar to the DSDP/International Phase of Ocean Drilling (IPOD) is a possibility. One country has already expressed interest in negotiating participation in OMDP. Other U.S. agencies, especially the U.S. Geological Survey and the Department of Energy may participate in OMDP according to their particular missions and interest.

FY 1981 Budget Highlights and Explanation of Increases and Decreases

Obligations

FY 1979 Actual	$11,624,910
FY 1980 Program	$19,475,000
FY 1981 Request	$27,300,000
Difference—FY 1981/FY 1980	$7,825,000

The $27,300,000 requested for the Ocean Drilling Programs is 40.2 percent more than the FY 1980 program of $19,475,000.

The distribution of the FY 1981 NSF funds budgeted between the two budget subactivities follows:

- Deep Sea Drilling Project/International Phase of Ocean Drilling is up $1,425,000 to $17,300,000.
- Ocean Margin Drilling Project is up $6,400,000 to $10,000,000.

The Deep Sea Drilling Project increase in NSF funding of $1,425,000 is necessary to cover increased costs for fuel, personnel and supplies and related expenses. The balance of the overall increase of $2,000,000 in DSDP is covered by increased foreign contributions.

The $6,400,000 increase in the Ocean Margin Drilling Project is needed to proceed from the OMDP planning and evaluation phase to project implementation. The $10,000,000 NSF budget for OMDP will be matched by industry contributions. This initial phase of implementation will take the project up to the point of modifications to *Explorer*, drilling system procurement, and drilling site selection, and will provide a basis for the final go, no-go decision for the project as a joint venture.

BIOLOGICAL, BEHAVIORAL, AND SOCIAL SCIENCES

FY 1981 PROGRAM TOTAL $182,000,000

Obligations by Subactivity

Subactivity	Actual FY 1979	Budget Request FY 1980	Current Plan FY 1980	Estimate FY 1981	Difference FY 1981-80
Physiology, Cellular and Molecular Biology	$62,292,455	$69,500,000	$67,218,000	$74,800,000	$7,582,000
Behavioral and Neural Sciences	33,073,342	36,900,000	35,443,000	38,700,000	3,257,000
Social and Economic Science	25,386,044	26,900,000	26,206,000	27,800,000	1,594,000
Environmental Biology	33,952,783	38,950,000	37,664,000	40,700,000	3,036,000
Total	$154,704,624	$172,250,000	$166,531,000	$182,000,000	$15,469,000

Goals and Description

The goal of the Biological, Behavioral, and Social Sciences (BBS) Activity is to expand knowledge and understanding of biological and social phenomena. The range of research supported includes acquiring rigorous physical and chemical information on the fundamental molecules of living organisms, the systems level interrelationships of organisms and their environment, the complex learning and behavior patterns of human beings, and the interactions of social, economic and cultural organizations and institutions.

Specific major objectives are to identify and fund research that will advance understanding of the:

- Molecular basis of structure and function in cells, organs, organ systems, and whole organisms;
- Interrelationships in terrestrial and freshwater ecosystems and key evolutionary relationships among the many species of plants, animals, and microorganisms.
- Biological, psychological, and cultural factors that underlie behavior; and
- Structure and function of economic and social institutions, and changes that impact on individuals and groups of the societal conditions they experience.

Over the long term, we expect the results of this fundamental research effort to contribute new ideas, options and opportunities for wisely utilizing the biological environment, maximizing human development potential, enhancing the quality of life, maintaining economic and social stability with progress, and increasing productivity.

The aims are ambitious, but to the extent that most national and international problems relate to people, their institutions and their interaction with the environment, the gain in understanding from this research can be invaluable.

FY 1981 Budget Highlights and Explanation of Increases and Decreases

Obligations

FY 1979 Actual	$154,704,624
FY 1980 Program	$166,531,000
FY 1981 Request	$182,000,000
Difference—FY 1981/FY 1980	$15,469,000

The Foundation's FY 1981 budget request for Biological, Behavioral, and Social Sciences (BBS) is $182,000,000, an increase of $15,469,000 (or 9.3 percent) over the FY 1980 level of $166,531,000. This increase will support the base of science in the program subactivities that follow and provide for selected new research opportunities. Important, but currently less promising, lines of inquiry will be reduced in order to fund the new research opportunities.

The distribution of FY 1981 budget requests for the four BBS program subactivities is based on a thorough review of research needs and opportunities and consideration of the research supported by other agencies. The percentage increases are as follows:

Physiology, Cellular and Molecular Biology	11.3
Behavioral and Neural Sciences	9.2
Social and Economic Science	6.1
Environmental Biology	8.1

Explanation of Increases:

- $7,582,000 increase, for a total of $74,800,000 for Physiology, Cellular & Molecular Biology including increases for:
  - studies of cell-cell interactions to increase our understanding of self recognition of cells in development and differentiation, and hormones and their receptors;
  - procurement of instrumentation and development of new instrumentation;
  - studies of membrane structure and function including pathways and movements of substances through membranes; and
  - research on the structure and function of macromolecules especially on the mechanism of heredity in the context of gene structure and functioning, biosynthesis of macromolecules, and the regulation of enzyme activity.
- $3,257,000 increase, for a total of $38,700,000 for Behavioral and Neural Sciences, including increases for:
  - studies of biochemical and hormonal mechanisms underlying behavior; and
  - anthropological research seeking human origins.

- $1,594,000 increase, for a total of $27,800,000, for Social and Economic Science, including increases for:
  - additional studies of economic instability, inflation and employment, both domestic and international; and
  - studies of allocation processes, decision rules, management behavior, and dispute resolution particularly in organizations such as large firms, government bureaucracies and other complex organizations.
- $3,036,000 increase, for a total of $40,700,000, for Environmental Biology including increases for:
  - research on various aspects of the ecology of crop and forest pests, acid rain, global carbon dioxide, and other pressing ecological problems; and
  - projects in long-term ecological research and maintenance of field research capability at representative sites.

ENGINEERING AND APPLIED SCIENCE

FY 1981 PROGRAM TOTAL **$137,000,000**

Obligations by Subactivity

Subactivity	*Actual FY 1979*	*Budget Request FY 1980*	*Current Plan FY 1980*	*Estimate FY 1981*	*Difference FY 1981/80*
Electrical, Computer, & Systems Engineering	$17,020,988	$18,160,000	$17,606,000	$22,500,000	$4,894,000
Chemical & Process Engineering	12,975,094	14,320,000	13,880,000	16,650,000	2,770,000
Civil & Environmental Engineering	8,151,770	9,630,000	9,300,000	10,125,000	825,000
Mechanical Sciences & Engineering	10,708,730	11,990,000	11,665,000	13,325,000	1,660,000
Applied Research	*17,608,213	*18,200,000	*17,628,409	*18,700,000	*1,071,591
Problem-Focused Research	*32,538,834	*30,400,000	*28,885,000	*30,500,000	*1,615,000
Intergovernmental Programs	5,131,539	5,000,000	5,500,000	7,000,000	1 500,000
Small Business Innovation & Industrial Technology	5,724,816	6,000,000	7,370,000	18,200,000	10,830,000
Total**	$109,859,984	$113,700,000	$111,834,409	$137,000,000	$25,165,591

*Does not include approximately $2.2 million (FY 1979) and $2.0 million (FY 1980 and FY 1981) in Applied Research and $1.4 million (FY 1979) and $1.8 million (FY 1980 and FY 1981) in Problem Focused Research for small business solicitations. These funds are now included and displayed in the Small Business and Industrial Technology subactivity.

**Does not include $0.9 million in FY 1979, $2.7 million in FY 1980 Budget Request, $3.85 million in FY 1980 Current Plan, and $2.7 million in FY 1981 for the Experimental Program to Stimulate Competitive Research, which is an EAS effort but displayed for budgetary purposes in the Cross-Directorate program.

Goals and Description

The Foundation's Engineering and Applied Science (EAS) Activity seeks to strengthen the Nation's engineering and applied science research base and enhance the links between fundamental research and applications in addressing selected national goals. This is accomplished by identifying and supporting basic research across a broad spectrum of the engineering sciences, applied research, and related activities that have the highest potential for contributing to the understanding and resolution of significant societal problems.

The specific objectives of EAS are to:

- Advance basic knowledge of fundamental engineering principles that might be applied to the analysis and design of a large variety of manmade systems;
- Strengthen the academic engineering research base in order to address the need for more basic research underlying industrial technology and for more graduating engineers working at the forefront of research.
- Stimulate the application of fundamental scientific and engineering knowledge to the solution of significant problems in the public and private sectors, and

shorten the time between scientific discoveries and their application for societal use:

- Focus U.S. scientific and technological capabilities on selected problems of national significance where NSF can make a unique contribution, such as earthquake hazards mitigation, human nutrition, and others;
- Increase fundamental scientific knowledge in selected problem areas where additional knowledge can contribute to their long-term solution;
- Provide mechanisms to increase the effectiveness of the public and private sectors in appropriately utilizing science and technology;
- Facilitate the integration of scientific and technical resources into the activities of State and local governments;
- Explore new ways to improve cooperation between universities and industry in research and industrial innovation; and
- Draw upon the research capabilities of the Nation's small businesses, with a view towards moving the most promising research along the continuum to commercialization as soon as possible.

On July 1, 1979, the National Science Foundation formed the Engineering and Applied Science Directorate by combining the Engineering activities within the Foundation with the Applied Science and Research Applications Directorate. Many activities between the two were highly complementary. By combining these organizations, NSF is now better able to:

- Strengthen the engineering programs of the Foundation by giving them a single, more visible place in the NSF organization;
- Enhance NSF's program of applied and problem-focused research by providing a broader base of science and engineering on which to build; and
- Recognize the key role of engineering in the transfer of science into technology by placing the Foundation's major engineering, industry-related, and problem-oriented efforts in one organization.

The EAS budget is organized around eight subactivities: Electrical, Computer, and Systems Engineering; Chemical and Process Engineering; Civil and Environmental Engineering; Mechanical Sciences and Engineering; Applied Research; Problem-Focused Research; Intergovernmental Programs; and Small Business Innovation and Industrial Technology.

Electrical, Computer and Systems Engineering supports, basic and applied research in large scale integrated circuit electronics, integrated optics, optical communications, automation and robotics, and mathematical studies of complex interactions in the manmade world.

Chemical and Process Engineering emphasizes research on: the basic mechanisms of catalysis and various chemical and biochemical processes, and the methods of putting the resulting knowledge into industrial applications; general theories of mass transfer and separation processes, including the characterization and processing of fine particles; and the efficient recovery and use of resources that feed important industrial processes.

Civil and Environmental Engineering focuses on: activities in which the earth's surface itself is involved (such as foundations and dams); the science of designing structures in such a way as to give the most efficient and economical service in response to given demands; and studies of the flow of above- and below-ground water, utilizing principles of engineering, biology, and chemistry to protect and improve the physical environment.

Mechanical Sciences and Engineering addresses problems in: the transfer of heat, a major carrier of power; solid mechanics, which emphasizes the problems of machines under high stress and strain; fluid mechanics, which looks at lubrication, questions of turbulence, and other areas connected with fluid flow; and mechanical systems, which involves the synthesis of all these elements into an appropriate "design."

Applied Research seeks to accelerate the rate of technological innovation growing out of significant advances in selected fields of science and engineering. The program supports unsolicited proposals as well as research in certain coherent areas; the latter involving the selective support of interrelated applied research projects having a high probability of providing a broad knowledge base for major technological innovations or for contributing to the solution of significant public policy issues.

Problem-Focused Research concentrates research on critical societal problems where it is clear that such research is essential for dealing effectively with the problems. Currently, four program areas are supported: Earthquake Hazards Mitigation; Alternative Biological Sources of Materials; Science and Technology to Aid the Handicapped; and Human Nutrition. The subactivity also supports efforts in: Problem Analysis, which examines a wide range of potential research topics and problem areas for use in selecting research directions; and Integrated Basic Research, which provides additional support to basic research topics related to problem areas of existing or emerging major importance.

Intergovernmental Programs supports research that attempts to facilitate the integration of scientific and technical resources into the activities of State and local governments. Efforts are directed not only at individual jurisdictions but also those encompassing statewide, regional, and national networks.

Small Business Innovation and Industrial Technology seeks to: develop selected incentives that the Federal government may use to increase R&D investment in the private sector, with particular emphasis on the role of small business in such activities; and combine the scientific and technological resources of universities and industries in cooperative efforts designed to accelerate industrial innovation and enhance productivity.

FY 1981 Budget Highlights and Explanation of Increases and Decreases

The proposed FY 1981 increase of $25,165,591, which will raise the EAS program from $111,834,409 to $137,000,000 in FY 1981, would incorporate the following increases:

- Electrical, Computer, and Systems Engineering by $4,894,000, from $17,606,000 in FY 1980 to $22,500,000 in FY 1981, primarily for a sharply-focused effort in microstructures and computer engineering research. Such an effort will address research in areas where the U.S. has recently been lagging in comparison to foreign countries, and also direct research towards a field which has high potential for productivity improvement and industrial innovation.
- Chemical and Process Engineering by $2,770,000, from $13,880,000 to $16,650,000, for efforts particularly in engineering energetics, with an emphasis on upgrading facilities for plasma chemistry and arc technology. Another thrust is in thermodynamics and mass transfer, with support for research in novel and energy-efficient separation processes.
- Civil and Environmental Engineering by $825,000, bringing that program from $9,300,000 to $10,125,000. Emphasis will be on research in structural mechanics, particularly as directed towards probabilistic design methods and optimization techniques on structures subjected to off-shore, wind, and earthquake environments.
- Mechanical Sciences and Engineering by $1,660,000, from $11,665,000 to $13,325,000. Concentration will be on mechanical systems research with emphasis on control theories as applied to manufacturing processes, which provide the foundation for later research in improved manufacturing methods and robotics.
- Applied Research by $1,071,591, raising the program from $17,628,409 to $18,700,000. Such an increase will allow for a new research thrust to examine the impact on the economy of a transition from heavily-regulated to less-regulated industries and services, and also to expand work in areas of manufacturing processes and materials handling.
- Problem-Focused Research by $1,615,000, from $28,885,000 to $30,500,000, principally for expanded efforts in earthquake hazards mitigation.
- Intergovernmental Programs by $1,500,000, from $5,500,000 to $7,000,000, to be applied entirely to the State Science, Engineering, and Technology Program and that program's efforts to implement capacity-building programs in State and local governments to access scientific and technological information.
- Small Business Innovation and Industrial Technology by $10,830,000, from $7,370,000 to $18,200,000, to accommodate significantly heightened efforts in support of small business research and university-industry cooperative research centers, both of which were keystones in the President's Industrial Innovation Initiative announced last fall.

Percentage changes between FY 1981 and the FY 1980 Current Plan for the subactivities are as follows:

Electrical, Computer & Systems Engineering	28%
Chemical & Process Engineering	20%
Civil and Environmental Engineering	9%
Mechanical Sciences & Engineering	14%
Applied Research	6%
Problem Focused Research	8%
Intergovernmental Programs	27%
Small Business Innovation & Industrial Technology	147%

SCIENTIFIC, TECHNOLOGICAL, AND INTERNATIONAL AFFAIRS

FY 1981 PROGRAM TOTAL $28,850,000

Obligations by Subactivity

Subactivity	Actual FY 1979	Budget Request FY 1980	Current Plan FY 1980	Estimate FY 1981	Difference FY 1981/80
International Cooperative Scientific Activities*	$10,603,513	$10,515,000	$12,014,000	$12,900,000	$886,000
Policy Research and Analysis	5,459,033	5,800,000	5,749,000	6,650,000	901,000
Science Resources Studies	3,071,607	3,200,000	3,188,000	3,400,000	212,000
Information Science and Technology	4,428,155	5,200,000	5,152,000	5,900,000	748,000
Total*	$23,562,308	$24,715,000	$26,103,000	$28,850,000	$2,747,000

*Excludes activities under the U.S.-U.S.S.R. Agreement on Cooperation in the Fields of Science and Technology which are presented separately in the Cross Directorate Program Budget.

Goals and Description

Science and technology are national and international resources. Domestically the scientific and technological enterprise of the United States yields new knowledge and practices which improve the quality of life and lead to new products, processes, and services. Abroad, science and technology are increasingly seen as a means to economic growth and social development. Efficient, effective, and timely international exchange of scientific information also contributes to U.S. international objectives. Science and technology more and more affect governing institutions, the industrial and academic sectors, and the role of individual citizens. Consequently, there is greater concern about science and technology policy and funding of the networks linking science and technology (S&T) to society at large.

The goal of the Scientific, Technological, and International Affairs (STIA) program activity is to promote the understanding and effective functioning of the Nation's scientific and technological enterprise. STIA supports activities designed to provide information and systematic analysis of the Nation's S&T enterprise, and to enhance domestic and international exchange of S&T information.

Each program subactivity contributes to attaining the overall STIA goal in a specific way. The Policy Research and Analysis subactivity pinpoints critical S&T policy issues through extramural and intramural research and examines the impact and effectiveness of alternative Federal policies for science and technology. Thus it contributes to the knowledge base for policy formulation. The Science Resources Studies subactivity develops comprehensive descriptions of the Nation's available human and financial resources for scientific and technological activities. Together, these two subactivities carry out most of the monitoring and policy research and analysis activities of STIA.

The remaining two subactivities are concerned with the improvement of S&T information exchange. International Cooperative Science programs benefit the U.S. scientific effort by gaining knowledge about scientific activities or resources in other countries and by promoting mutually beneficial cost and facility sharing. At the same time, these programs help the United States to implement foreign policy objectives which have S&T content. The Information Science and Technology subactivity supports basic and applied research leading to timely and resourceful use of information especially by the science and technology enterprise.

FY 1981 Budget Highlights and Explanation of Increases and Decreases

Obligations

FY 1979 Actual	$23,562,308
FY 1980 Program	$26,103,000
FY 1981 Request	$28,850,000
Difference FY 1981 - 1980	$2,747,000

The FY 1981 budget request for STIA, $28,850,000, exceeds the FY 1980 Current Plan by 10.5 percent, or $2,747,000. Through internal adjustments and no growth restrictions in some ongoing programs, this small increase nonetheless maintains the three international cooperative science thrusts of FY 1980 and permits other strategically planned activities in each of the four subactivities. Percentage increases in the subactivities follow:

International Cooperative Scientific Activities	7.4%
Policy Research and Analysis	15.7%
Science Resources Studies	6.0%
Information Science and Technology	14.5%

Program increases are described below:

International Cooperative Scientific Activities. Ongoing programs and exchanges, including the thrusts initiated in 1980, are maintained, although they continue to face dollar value pressures overseas. The requested $886,000 increase will:

- Expand the cooperative research thrust in Western Europe where scientific and technical capabilities in some fields rival or surpass those in the U.S. and where U.S. scientists can benefit most from cooperation ($286,000), for a total program of $1,800,000.
- Cover significantly increased dues and operating costs associated with U.S. participation in international scientific organizations ($500,000; total program, $4,100,000).

- Enable approximately one hundred more U.S. scientists and engineers to participate in major international conferences ($100,000; total program, $800,000).

Policy Research and Analysis

- An increase of $750,000 initiates a new research and analysis program in international economic policy that will build upon current work focusing on international technology transfer.
- An increase of $151,000 permits additional risk analysis activities to improve methods for evaluating long-term comparative risks and benefits of alternative technologies.

Science Resources Studies. Completion of several large studies funded in FY 1980 and an increase of $212,000 permits:

- A key survey of U.S. scientists and engineers identified by the 1980 Decennial Census. This continues a thrust begun in FY 1979 which has planned, sequential phases running through 1984. The data obtained will serve as a base for the Federal Government's statistical information on the adequacy, distribution, and characteristics of the Nation's S&T personnel.

- Support of two special projects designed to update the Nation's information and data concerning small R&D firm's industrial activity and the R&D of independent nonprofit institutions.

Information Science and Technology

- An increase of $748,000 allows growth in three program elements: support of research on information transfer and related human behavior aspects ($400,000); investigations of the information economy ($148,000); and research on new and promising information technology ($200,000).

CROSS-DIRECTORATE PROGRAMS

FY 1981 PROGRAM TOTAL $51,950,000

Obligations by Subactivity

Subactivity	Actual FY 1979	Budget Request FY 1980	Current Plan FY 1980	Estimate FY 1981	Difference FY 1981/80
Industry/University Cooperative Research	$5,445,929	$4,000,000	$7,050,000	$20,000,000	$12,950,000
Special Facilities and Instrumentation Programs	5,606,302	5,800,000	8,100,000	20,250,000	12,150,000
Cross-Directorate International Programs	3,387,484	3,200,000	4,200,000	5,200,000	1,000,000
Other Programs	2,423,171	4,300,000	6,175,348	6,500,000	324,652
Total	$16,862,886	$17,300,000	$25,525,348	$51,950,000	$26,424,652

Goals and Description

The Cross-Directorate Programs Activity is new in the FY 1981 budget. The Foundation has grouped in this budget activity, for presentation purposes, a number of programs with special characteristics and goals. These programs mainly provide funds for purposes not related to any single field of science but to several scientific fields generally supported by the NSF. In some cases, these programs receive and review proposals in many areas aimed toward a specific objective other than advancing a particular field of science. One program, for example, provides equipment to researchers at small colleges and another experiments with building research linkage between academia and industry. Both programs support projects in many fields of science.

Some of the goals of individual programs included in the Cross-Directorate Program Activity are to:

- Encourage greater cooperation in research between universities and industry.
- Provide support for research equipment and improved research facilities to colleges and universities that have programs in the sciences and engineering.
- Maintain research cooperation between the U.S. and the U.S.S.R. and broaden opportunities between the U.S. and China.
- Help predominantly minority colleges and universities establish active research programs on their campuses thereby encouraging capable scientists at these institutions to compete for research support from all appropriate sources.

- Improve the quality of science by stimulating and increasing the competitiveness of scientists for Federal research support in States that are now relatively less able to compete successfully.
- Provide postdoctoral opportunities for recent doctoral graduates to pursue full-time basic research that enhances their ability to make significant contributions to the scientific world.
- Provide support for research in decision and management sciences aimed at the improvement of decision making in the public and private sectors.
- Continue support of efforts to plan and evaluate Foundation programs on the basis of established needs, goals, and objectives.

PROGRAM DEVELOPMENT AND MANAGEMENT

FY 1981 Program Total $60,800,000

Obligations by Subactivity

Subactivity	Actual FY 1979	Budget Request FY 1980	Current Plan FY 1980	Estimate FY 1981	Difference FY 1981/80
Mathematical and Physical Sciences	$4,154,420	$5,242,000	$4,755,000	$4,822,000	$67,000
Astronomical, Atmospheric, Earth and Ocean Sciences	4,911,017	5,538,000	5,787,000	5,987,000	200,000
Biological, Behavioral and Social Sciences	3,643,141	4,592,000	4,798,000	4,864,000	66,000
Science Education Programs	3,543,928	3,825,500	3,820,000	3,820,000	—0—
Engineering and Applied Science	5,151,927	5,463,500	5,864,000	5,964,000	100,000
Scientific, Technological and International Affairs	6,396,024	6,497,000	6,718,000	6,761,000	43,000
Executive Management	6,389,967	7,926,000	7,458,000	7,631,000	173,000
Central Support Services and Administration	20,575,474	20,516,000	21,363,762	20,951,000	-412,762
Total	$54,765,898	$59,600,000	[2,3]$60,563,762	$60,800,000	$236,238
Full Time Permanent Positions[1]	1,260	1,280	[4]1,274	1,293	19

[1] Includes 12 reimbursible positions

[2] Includes $2,547,762 FY 1979 PDM carryover funds

[3] Excludes $64,000 transferred to Department of Education

[4] Excludes 6 positions transferred to Department of Education

Organization and Objectives

The goal of the Program Development Activity and Management is to achieve the most effective management of the National Science Foundation. Major objectives of this activity are to:

- operate a system of impartial evaluation and selection of proposals to ensure support of research and science education projects on the basis of scientific merit;
- provide a sufficient staff of well-trained and highly qualified scientists, educators, administrators, and support personnel;
- supply support services to provide staff an environment conducive to effective program and management operations;
- ensure proper accountability and oversight of Federal funds through effective management policies, procedures, and techniques;
- maintain an in-house capability for high quality analysis of science and technology policy;

- identify issues and develop long-range plans for effective and responsive NSF programs; and
- obtain oversight by outside experts and in-house staff to ensure vitality and responsiveness of NSF programs.

NSF is organized into six program directorates, an administration directorate, and six staff offices reporting to the Director. Within this structure, the six program directorates operate and manage the major discrete parts of the Foundation's efforts in science research.

Three of the directorates, each composed of related groups of scientific disciplines, strongly represent basic research programs in the top management level. These directorates are Mathematical and Physical Sciences; Astronomical, Atmospheric, Earth, and Ocean Sciences; and Biological, Behavioral, and Social Sciences.

The other directorates manage research in applied science and engineering; science education; and a consolidation of international science programs, science information activities, science resources studies, and science policy analysis. These directorates are Engineering and Applied Science, Science Education, and Scientific, Technological, and International Affairs.

The staff offices reporting to the Director are Planning and Resources Management, Equal Employment Opportunity, Government and Public Programs, General Counsel, Small Business Research and Development, and Audit and Oversight.

In addition to managing and operating science research programs through grants and contracts, the NSF staff conducts in-house efforts related to:

- studies of science resources, including scientific manpower;
- evaluation of science policy issues and alternatives in support of the National Science Board and the Office of Science and Technology Policy;
- coordination of national and international scientific activities;
- planning and management of a complex logistic support for the U.S. Antarctic Research Program;
- planning and managing the expanded ocean drilling programs; and
- a science liaison staff maintained at Tokyo, Japan, to assist coordination of science programs involving Far Eastern countries.

FY 1981 Budget Highlights and Explanation of Increases and Decreases

The FY 1981 estimate of $60,800,000 for Program Development and Management is an increase of $236,238 over the estimate for FY 1980.

A total staff of 1,293 positions is planned for FY 1981, an increase of 19 positions. Six of the new positions were identified for support of basic and applied research efforts by the NSF staffing study completed in the fall of 1979. Eight are needed in connection with the expanded program of ocean drilling. Of the remaining five positions, three are allocated to the expanded program for research facilities, one to the small business research program, and one for the Five-Year Outlook in Science report authorized by the Science and Technology Policy Act of 1976.

FY 1981 increases and decreases are:

- An increase of $456,000 for permanent personnel compensation for salary costs of the additional 19 positions. This initial funding is approximately two-thirds of the annual cost of these positions and the balance will be annualized in FY 1982;
- An increase of $25,000 for consultant compensation to fund about 250 more consultant days performed by outside experts to provide oversight and advice concerning NSF programs;
- An additional $63,000 for personnel benefits as the employer's contributions to retirement and insurance for the additional 19 positions and for increased costs of benefit payments for the existing staff.
- A total increase of $146,000 is provided for travel. This item covers additional site visits for monitoring and oversight of program awards by existing staff, and 19 new employees, advisory committees, and consultants for new programs.
- An increase of $50,000 for transportation of things for household moves of new employees.
- A net decrease of $235,000 in rents and communications, resulting from an increase of $200,000 in space rental rates assessed to NSF by the General Services Administration and a decrease of $435,000 in rental costs for data processing equipment previously leased but now purchased.
- An increase of $50,000 for printing and reproduction due to increased costs of paper, printing supplies, and printing by the Government Printing Office and private contractors.
- A decrease of $108,762 in administrative services contracts previously budgeted for software development.
- A net decrease of $210,000 resulting from reduced purchases of special purpose equipment and computer hardware.

SCIENCE EDUCATION

FY 1981 PROGRAM TOTAL **$85,700,000**

Obligations by Subactivity

Subactivity	Actual FY 1979	Budget Request FY 1980	Current Plan FY 1980	Estimate FY 1981	Difference FY 1981-80
Scientific Personnel Improvement	$33,071,847	$32,900,000	[1]$31,600,000	$35,200,000	$3,600,000
Science Education Resources Improvement	28,605,692	29,100,000	[2]24,000,000	24,200,000	200,000
Science Education Development & Research	12,014,423	15,300,000	14,950,000	17,500,000	2,550,000
Science & Society	6,287,455	7,400,000	7,650,000	8,800,000	1,150,000
Total	$79,979,417	$84,700,000	[1,2]$78,200,000	$85,700,000	$7,500,000

[1] Includes $1.0M to be obligated by the Pre-College Teacher Development in Science Program in January 1980 for summer projects for teachers in Grades K-4, but excludes $1.5M for academic year projects scheduled for obligation after April 1, 1980, the date for establishment of the Department of Education. This latter amount will at that time be transferred to the new Department.

[2] Excludes $5.0M which is being transferred to the Department of Education as of April 1, 1980.

Goals and Description

The National Science Foundation Act of 1950 (P.L. 81-507, as amended) directs the Foundation to "... initiate and support ... programs to strengthen ... science education programs at all levels. ..." From this mission flow two continuing goals for the Science Education Program in FY 1981:

- To help all citizens increase their basic understanding of science and its contributions to the quality of life; and
- To assure a stable flow of the most talented students into careers in the sciences, with particular reference to increasing the participation of minorities and women.

To implement these goals the Science Education staff, working closely with the Congress, the National Science Board and the scientific community, has developed a balanced and carefully integrated set of program mechanisms. The objectives of these programs are to:

- Support research on how science and mathematics are learned and development of more effective instructional techniques and materials for use at all levels of education.
- Provide high quality training in science for specially selected students in programs ranging from the junior high school through the graduate levels.
- Provide for subject-matter revitalization of both pre-college teachers of science and undergraduate science faculty.

- Assist in the improvement of undergraduate science instruction at 2-year and 4-year colleges and universities; and
- Improve the public's understanding of science and how it affects their daily lives thus increasing the ability of citizens to participate knowledgeably in the resolution of science-related public policy issues.

In pursuing these objectives the Foundation will place special emphasis on four priority thrusts. Two of the four thrusts were initiated in FY 1979. The first of these is the improvement of science education for the early adolescent. This entails focussing continued effort at a point of high opportunity, the junior high/middle school years. What we know about this age group tells us that many choose not to study science and mathematics beyond this age and that this is particularly true of minorities and girls. We need to know more about why this phenomenon occurs at this age level and what needs to be done to alter the situation so that these students have a broadened understanding of science and that they do not preclude themselves from possible preparation for future science and technology-related careers.

The second of the thrusts initiated in FY 1979 is that of improved access of under represented minorities and women to careers in science and engineering. The matter of career access, while related to the early adolescence thrust, is of sufficient importance to continue to set this subject forward as a particular science education concern.

The third priority thrust, initiated in FY 1980, relates to out-of-classroom or informal science learning experiences. This is an important factor in the general development of the public's understanding of science, and is of great importance in interesting and motivating children to study science. Elementary school enrollments are shrinking drastically. Yet within this reduced school enrollment are the scientists who will be entering the scientific labor force at the turn of the century. With a smaller pool to draw from, science must command a greater proportion of talented young students to assure an adequate labor force two decades hence. The motivational aspects of informal, out-of-classroom science learning in the current decade is expected to play an important role in the development of the cadre of scientists of the future.

This year a fourth priority thrust is added to the above continuing concerns—revitalization of college science teaching. For the past several years, higher education (undergraduate institutions in particular) has been affected by a series of events which have, in a cumulative way, affected the quality and currentness of college teaching of science. Declining student enrollments due primarily to birthrate changes have affected faculty mobility and reduced the need for new faculty. This, in conjunction with tenure, has brought about a consequent aging of faculty. In addition, the changing character of the student body and changing patterns in the job market have made the content of many course offerings obsolete. Because of these factors the Foundation is proposing to give priority, as a new major thrust for FY 1981, to the updating of the subject-matter competence of college science faculty.

The program structure necessary to achieve this plan is already in place. It consists of four program subactivities, which are administrative groupings of program elements having similar objectives. They are:

Scientific Personnel Improvement—Programs in this subactivity are designed to improve subject-matter competence of pre-college and college science teachers and students; and to identify and encourage the talented, particularly minorities, women and the physically handicapped, to participate more fully in the study of the sciences, mathematics and engineering.

Science Education Resources Improvement—This group of programs is designed to bring about the improvement of instruction in the sciences in schools, 2-year and 4-year colleges, and universities and provide validated knowledge concerning effective instructional strategies and research results in education in the sciences for use by decisionmakers in science education.

Science Education Development and Research—These two programs support scientists and practitioners who are trying to advance our basic knowledge of how the concepts, processes and skills of science are learned and encourage the development of new, more effective materials and methods of instruction, without which the improvement of science education cannot proceed in an orderly fashion.

Science and Society—The programs in this subactivity seek to bring about greater general understanding of science and technology, the connections between them, and the human value implications of both for contemporary life.

Within this program structure the Foundation plans to implement its four priority thrusts. In the accomplishment of this, the strategy initiated in FY 1979 will be continued. This strategy requires that, wherever appropriate in the several science education program mechanisms, special efforts will be made to allocate regular program resources to the furtherance of these priority thrusts. The importance of these priorities in the achievement of the two major goals stated above demands that they be incorporated into each applicable program rather than being isolated as separate or discrete functions.

In addition to these priority concerns, the Foundation's traditional concerns for the support of those students having the greatest talent for study and research in science and for improving the quality of science instruction in junior/community colleges and in 4-year colleges will be continued in FY 1981. The effectiveness of our Nation's leaders—scientists and non-scientist—is directly dependent upon the quality of instruction provided in our institutions of higher eduction.

FY 1981 Budget Highlights and Explantion of Increases and Decreases

Obligations

FY 1979 Actual	$79,979,417
FY 1980 Program	$78,200,000
FY 1981 Request	$85,700,000
Difference—FY 1981-FY 1980	$7,500,000

The amount requested for the FY 1981 Science Education Program Activity is $85,700,000. This represents a 9.6 percent increase over the adjusted Current Plan for FY 1980, $78,200,000.

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Given the adjustments in the Science Education Current Plan caused by the ansfers to the Department of Education, the percent change between FY 1980 and FY 81 for the four Science Education Subactivities are:

Scientific Personnel Improvement	11.4%
Science Education Resources Improvement	0.8%
Science Education Development & Research	17.1%
Science and Society	15.0%

Program areas increased in FY 1981 include:

- $425,000 for Graduate Fellowships and Traineeships to provide for increased stipend support.
- $820,000 for Student-Oriented Programs to increase support for special education opportunities in science for middle-school and high school students and for Undergraduate Research Participation.
- $1,011,000 to increase support for improvement of undergraduate instruction in science through the upgrading of subject-matter backgrounds of science faculty.
- $1,359,000 to increase support for minority high school students and for women to increase the access of these underrepresented groups in the scientific and technological labor force.
- $522,000 for improving undergraduate instruction in science through Local Course Improvement.
- $404,000 for Information Dissemination in Science Education to increase the support of activities designed to bring to education decisionmakers information about new instructional materials and techniques and the results of research into the learning of science which can be utilized to improve education in science, including a new emphasis on the dissemination of information on instruction in science in 2- and 4-year colleges.
- $523,000 to increase the Research in Science Education Program for developing new knowlege about the processes by which science is learned and the motivational factors involved in pursuing science as a career.
- $2,035,000 for Development in Science Education to create new instructional materials and techniques primarily to be applied to the furtherance of the Foundation's four Science Education priority thrusts—improvement of educational opportunities for early adolescents, career access for minorities, and women, informal out-of-classroom instructional materials and systems, and the quality of science teaching in higher education.
- $1,080,000 to increase utilization of museums and similar community resources in improving the public's understanding of science and its role in their daily lives.

Programs or projects reduced or eliminated:

- Postdoctoral Fellowships have been transferred to the Cross-Directorate Program section of this budget document.

- The Student-Originated Studies Program has been combined with the Undergraduate Research Participation Program with no loss of support for the group served, undergraduate students.
- The Minority Institutions Science Improvement Program is transferred pursuant to P.L. 96-88, the Department of Education Organization Act of 1979, as well as that portion of the Pre-College Teacher Development in Science Program which involved primary grade (K-4) teachers.
- $448,000 decrease in the Comprehensive Assistance to Undergraduate Science Education Program and a $286,000 decrease in the Instructional Scientific Equipment Program. These decreases are more than offset by increases in other programs which focus directly on the improvement of undergraduate science education.

Thus, the highlight of the FY 1981 Science Education Program activity is its emphasis on increasing those resources allocated to the support of a broad spectrum of activities which will:

- Improve the science instruction of early adolescents, and in particular minorities and girls, to equip them better to appreciate how science affects their daily lives and motivate them to continue the study of science so as not to preclude possible career choices in science and technology;
- Improve study and research opportunities for minorities and women and identify the social, psychological and instructional barriers which these groups face in pursuing careers in science; and, further, to explore and develop the means to alleviate those barriers;
- increase the number and kind of informal out-of-classroom learning experiences in science, particularly for children, to improve their understanding of science and technology as it touches their lives and to encourage them to delve deeper into the study of science for their personal edfication and possible career utilization; and
- Increase opportunities for college science faculty to upgrade their science backgrounds and to make their course offerings more effective and relevant to the scientific manpower requirements of the future.

In implementing these emphases the Science Education Program will focus on individuals by: 1) identifying talented students at the junior high through graduate school levels and providing special opportunities for extending their education in science; 2) supporting faculty members who wish to update their science subject-matter competencies and improve the quality and relevance of the courses they teach; 3) seeking out and supporting the most talented of those working in the area of science education research and development; and 4) bringing to all citizens an understanding of science through use of the informal education mechanisms with which they interact on a day-to-day basis.

SPECIAL FOREIGN CURRENCY

FY 1981 PROGRAM TOTAL **$5,500,000**

Obligations by Subactivity

Subactivity	Actual FY 1979	Budget Request FY 1980	Current Plan FY 1980	Estimate FY 1981	Difference FY 1981/80
Research & Related Activities	$3,836,241	$4,900,000	$4,903,374	$4,400,000	$-503,374
Science Information	165,000	1,100,000	600,000	1,100,000	500,000
Total	$4,001,241	$6,000,000	$5,503,374	$5,500,000	$-3,374

Goals and Description

The National Science Foundation supports science activities in Egypt, India and Pakistan utilizing U.S.-owned foreign currencies designated by the Department of the Treasury as excess to the requirements of the U.S. Government. In this way the National Science Foundation is able to support scientific activities of benefit to the United States and participating foreign countries without exporting dollars. The objectives of the overall activity are pursued chiefly through grants for research and related activities and contracts for the translation into English of technical literature from foreign languages. This activity supports:

- Participation by U.S. scientists and institutions in international cooperative science projects.
- Translations of scientific and technical literature.

FY 1981 Budget Highlights and Explanation of Increases and Decreases

Obligations

FY 1979 Actual	$4,001,241
FY 1980 Program	$5,503,374
FY 1981 Request	$5,500,000
Difference—FY 1981-FY 1980	$-3,374

The $5,500,000 requested for the Special Foreign Currency Program Activities is slightly less than the FY 1980 program of $5,503,374.

Percentage Changes in Subactivities

Research and Related Activities	-10%
Science Information	83%

In FY 1981, the Special Foreign Currency Program activities will provide excess currencies in the following dollar equivalents:

- Research and related activites in India and Pakistan ($4,200,000). This total will provide support for new and continuing cooperative research activities and travel for U.S. scientists to attend important scientific meetings abroad.
- Support of cooperative research activities in Egypt ($200,000). This amount representing a reduction of $500,000 from the FY 1980 level, is due to the depletion of SFC reserves in Egypt. Funds will be used to complete existing projects.
- Translations into English from foreign language scientific publications by contractors in India and Pakistan ($1,100,000); an increase of $500,000 to restore the overall program to the annual level of previous years. This is consistent with the recent White House initiatives on innovation highlighting enhancement of the transfer of information from other countries.

EXPLANATION OF PRIOR YEAR CARRYOVERS

In addition to the FY 1980 appropriation, there is $3,343,893 in unobligated funds carried forward from prior years' appropriations, composed of the following:

- *No-Year Funds Carried Forward into FY 1980 ($629,348)*—Prior to FY 1974, NSF appropriations were made on a no-year basis and unobligated balances are available until expended. As a result of closing out expired accounts and reconciling NSF and university records, $629,348 of previously obligated funds were deobligated during FY 1979 but too late to be incorporated into FY 1979 program plans. These funds are being carried into FY 1980 and will be used for basic research in the Mathematical and Physical Sciences ($236,000) and for the Cross-Directorate program of NSF Planning and Evaluation ($393,348).
- *Program Development and Management ($2,547,762)*—An unobligated carryover balance was generated in FY 1979 due to stringent controls imposed by NSF on PD&M funds in response to the Congressional recommendation by the Chairman of the Appropriation Subcommittee on HUD-Independent Agencies that a minimum of $2,500,000 should be carried forward into FY 1980 and applied to cover pay cost requirements resulting from the FY 1979 pay raise legislation.
- *FY 1979 Carryover ($163,409)*—This balance represents one fiftieth of one percent of the FY 1979 Research and Related Activities Appropriation, excluding PD&M. These funds will be used to provide partial support for orderly close-out of projects in the Chemical Threats Program in the Applied Science section of the Engineering and Applied Science Activity. This allocation is within the Congressional limitation of the FY 1979 funds appropriated for the Applied Science and Research Applications (ASRA).
- *Special Foreign Currency Carryover ($3,374)*—These funds will be reallocated in FY 1980 to the Special Foreign Currency Program.

The CHAIRMAN. Dr. Hackerman, do you have a statement?

I would like so say that all of the statements will be made a part of the record, in full, so if you want to summarize, that will be fine.

Dr. HACKERMAN. Thank you, Mr. Chairman. That's precisely what I would like to do, rather than read it.

[A biographical sketch of Dr. Hackerman follows:]

DR. NORMAN HACKERMAN

Born Baltimore, Maryland, March 2, 1912; son of Jacob and Anna (Raffel) Hackerman; married Gene Allison Coulbourn, August 25, 1940; children—Patricia Gale, Stephen, Sally, Katherine.

A.B., Johns Hopkins University, 1932, Ph.D., 1935.

Assistant professor, Loyola College, Baltimore, 1935–39; research chemist, Colloid Corporation, 1936-40; chemist, U.S. Coast Guard, Staten Island, 1939–41; assistant professor of chemistry, Virginia Polytechnic Institute, Blacksburg, 1941–43; research chemist, Kellex Corportation, 1944–45; assistant professor of chemistry, University of Texas, Austin, Austin, 1945–46, associate professor, 1946-50, professor, 1950–70, chairman of department, 1952–61, director, corrosion research labortory, 1948–61, dean, research and sponsored programs, 1960-61, vice president, provost, 1961–63, vice chancellor for academic affairs, 1963–67, president, 1967–70; professor of chemistry, William Marsh Rice University, Houston, 1970—, president, 1970—; consultant in corrosion, 1946—, in surface chemistry, 1948—.

Chairman, Gordon Research Conference on Corrosion, 1950, on Chemistry at Interfaces, 1959, member, board of trustees, 1970–73; chairman, Inter Society Corrosion Committee, 1956–58; member, board on energy studies, National Academy of Science/National Research Council, chairman, 1974—; member, National Board on Graduate Education, 1971–76; member, National Science Board, 1968—, chairman, 1974—; chairman, council presidents University Research Association, 1973; member, environment pollution panel, President's Science Advisory Committee, 1965–66; consultant, Association Universities for Research in Astronomy, 1964—; member, science and educational advisory committee, Lawrence Berkeley Laboratory; chairman, board of trustees, Argonne Universities Association, 1969–73.

Recipient, Whitney award, National Association of Corrosion Engineers, 1956; Joseph J. Mattiello Memorial lecturer, Federation of Societies of Paint Technology, 1964; Southwest Regional award, American Chemical Society, 1965; Palladium medalist, Electrochemical Society, 1965.

Fellow, New York Academy of Sciences, American Association for the Advancement of Science; member, National Academy of Sciences, American Chemical Society (board of editors, monograph series, 1956–62, executive committee, colloid division, 1955–58), Electrochemical Society (honorary member, president, 1957–58), Faraday Society, American Association for the Advancement of Science, American Philosophical Society, National Association of Corrosion Engineers (director, 1952–55, chairman, A. B. Campbell Young Authors Award committee, 1960–), International Society for Electrochemistry, Sigma Xi, Phi Lambda Upsilon, Alpha Chi Sigma, Phi Kappa Phi.

Technical editor, Journal of the Electrochemical Society, 1950–68, editor, 1969—; interim editor, Electrochemical Technology, 1965–68, adviser, editorial board, Corrosion Science, 1965—; editorial board, Catalysis Reviews, 1968–73; contributor of numerous articles to scientific journals.

Home: President's House, William Marsh Rice University, Houston, Texas 77001.

STATEMENT OF DR. NORMAN HACKERMAN, CHAIRMAN, NATIONAL SCIENCE BOARD

Dr. HACKERMAN. Mr. Chairman and members of the committee, I would like to highlight a few points in my statement.

One is that I will complete my second term as a member of the National Science Board in May. Two terms—12 years—is the statutory limit. It has been a great privilege to serve on the Board and to appear before the distinguished members of this and other Congressional committees. It's one way in which scientists can serve the country, and I urge my colleagues to dedicate themselves to this kind of activity.

The CHAIRMAN. Let me just say, Dr. Hackerman, we certainly appreciate the time and effort and sacrifices that you've made to serve your country and the science community, and your very distinguished service as Chairman of the National Science Board. I know it's taken a lot of time from other duties that you have and which you perform so well. But on behalf of the Committee on Science and Technology let me express our deep appreciation for the dedication and great service that you've rendered your country. We appreciate it very much.

Dr. HACKERMAN. Thank you, sir. In the 12 years during which I have served on the Board, some changes have taken place. One of your questions pertains to that, so I won't answer it specifically. I would like to point out that there is both change and constancy.

At the first NSB meeting I attended, we talked about young investigators and the fact that there wasn't enough support for them, the Antarctic research program and its importance, and legislation which was then pending with regard to the Foundation's organic act. We are now again discussing those topics.

I would like to make the point that the reason is that they were issues then and they are issues now. Issues often remain unresolved. In fact, the kinds of issues that face the scientific community and the country and your committee, I think, are long-lived. Times and conditions change. One has constantly to assess the structure in use against conditions as they exist at that time. This is legitimate. It doesn't indicate immobility. It simply indicates that we should review the matter regularly.

One of the important things that occurred in my time on the Board was the introduction of the series of National Science Board Reports. There have been discussions, even arguments, as to the value and usefulness of the reports, the time and effort required to produce them, whether they might not be done some other way, scheduling, and so forth. Regardless of those discussions, the reports have had an impact. The sequence of reports known as Science Indicators have been of special consequence. Many of the current debates on science and technology stem from information contained in these reports. The most recent one, "Science Indicators—1978," has just been published. It hasn't been out long enough to be evaluated properly, but I think you will find it contains information of some consequence.

The 1980 indicators report is underway. It may include a chapter on the quality of science, something that we haven't attempted before. I say "may" because the Committee on the Thirteenth NSB Report has commissioned such an activity, but has not yet decided whether they will use it. If there is such a chapter, it will be a sizable step forward in adding a qualitative aspect to the quantities that we tabulate.

I have asked the staff to leave a copy of another report, "Status of Science Reviews—1980," with you. It provides background for the Board's planning and budgeting activities. It includes some statements about current directions and opportunities in the fields of science supported by NSF.

There is great hesitancy to talk about where science is going, in part because one scientist doesn't really like to speak for another, and also because there are differences of opinion about future directions in science. There is one thing that's very evident, and Dr. Atkinson has already alluded to it. He said there is a clear "convergence" of science, science which diverged a couple of hundred years ago, or perhaps 100 years ago, divergence in science occurred as investigators began to specialize in order to examine more carefully smaller and smaller segments of the system. Science has now come to the position where we, collectively, understand enough so that we can now hope to approach such questions as that of the effect of CO_2 in the atmosphere. That really wasn't possible a few years ago. It may not be possible now, but at least we have the background and the courage to approach the question. You'll notice I haven't called it a problem. That's a different question. It may not be a problem.

But at least we're willing to do that. We're willing to undertake activities such as the global atmosphere research program. We're willing to look at major systemic kinds of activities in the Earth's function because, in my opinion, we've learned how to make science converge, both within fields and across fields. That, to me, is very important.

I believe that science is in great shape. Scientists may not be, but science is in great shape, and it's important that we understand that. Scientists' personal requirements may not be met completely, but the field itself is good.

The section of my statement on the role of the National Science Board is a brief, but not complete, statement of what the Board does. I would add that the National Science Board plays a major role in policy formulation for NSF through its recommendations on important staff members; that is, the Director, the Deputy Director, and Assistant Directors. That is not noted in my statement, and it should be.

Dr. Atkinson has stated clearly the background and basis for NSF's proposed program for fiscal year 1981 as contained in the President's budget. The Board strongly supports that program. We believe that the funds, if authorized and appropriated, could be effectively used to move science forward in a constructive, serious, and important way.

In closing, I would like to mention a particular, personal concern: the production of scientificially literate citizens who have a basic understanding of science sufficient for them to participate in choosing among the increasingly numerous and important science-based issues facing us. It is a task that should be emphasized during the next few years.

Mr. Chairman and gentlemen, I appreciate the opportunity to speak. Thank you for your understanding and support of science and the National Science Foundation.

The CHAIRMAN. Thank you very much, Dr. Hackerman.

[The prepared statement of Dr. Norman Hackerman follows:]

Statement of Dr. Norman Hackerman
Chairman, National Science Board
Before the Committee on Science and Technology
U. S. House of Representatives
January 30, 1980

Mr. Chairman, Members of the Committee:

It is a pleasure for me to be present today at this posture hearing on the National Science Foundation (NSF). This is the last occasion on which I will appear before this Committee as Chairman of the National Science Board (NSB), as my second term as a Member of the Board will expire this spring. I consider it an honor and a privilege to have had the opportunity to serve on the Board over those twelve years and to have been associated with my fellow Members and the distinguished Members of this Committee.

During those years there have been many changes in the Foundation. Leland J. Haworth, the Director in 1968, was succeeded by William D. McElroy in 1969, and by H. Guyford Stever in 1972. Richard C. Atkinson joined the National Science Foundation in 1975 as its Deputy Director and was sworn in as Director by President Carter on June 1, 1977. The Board has always enjoyed a close working relationship with the Director of the Foundation. With the present Director, it has been especially so.

The Foundation's budget has almost tripled, going from approximately $400 million in 1969 to this year's request of $1.148 billion. The increase reflects the additional responsibilities that the Foundation has been asked to assume during that time, the most important of which, perhaps, has been the real growth in its support of basic and applied research.

Among the items discussed at the first NSB meeting I attended were support of young investigators, the Antarctic Research Program, and proposed legislation amending the Foundation's organic Act. We are discussing these topics now, too, but the Board is doing much more today. In 1967 the Board met five times; in 1980, it will meet nine times. This has resulted in part from the Board's growing conviction that it could best make policy by keeping in closer contact with the Foundation's activities. This led to a number of changes, including a change in the operations of the Programs Committee, established in 1968, an increase in its activities and, in turn, those of the Board.

On July 18, 1968, the President signed Public Law 90-407, which amended the National Science Foundation Act of 1950. Included in that legislation was the requirement that the Board assess the status and health of science and its various disciplines, including such matters as national resources and manpower, in reports rendered annually to the President for submission to the Congress. The Board views this requirement as an honor and a privilege. The first report, *Toward a Public Policy for Graduate Education in the Sciences*, was published in 1969. The Eleventh NSB Report, *Science Indicators--1978*, was transmitted by the President to the Congress on November 19, 1979.

From the latter report we can draw some conclusions about the current state of science and technology in this country. Certainly there are some areas that must be watched carefully, but, overall, our scientific enterprise remains sturdy. A welcome development within the larger context is the relative gain in scientific potential of some other nations, such as Japan and West Germany.

Some highlights from Science Indicators--1978, the Board's latest annual report, are listed below.

International Aspects:

- U. S. investment in research and development (R&D) is much greater than in most countries, both in terms of expenditure and scientific and technical personnel. However, Japan and West Germany have been increasing their R&D investments more rapidly than has the United States.

- The number of scientists and engineers engaged in R&D as a proportion of the total labor force is increasing in other countries relative to the United States. In absolute terms the United States has more R&D scientists and engineers than any other country except the Soviet Union.

- Almost 40 percent of the articles in the 2,100 most highly cited scientific and technical journals of the world is accounted for by U. S. authors. This overall proportion has remained fairly stable over the five-year period between 1973 and 1977.

- U. S. universities and colleges have made a significant contribution to the building of world scientific and technical capabilities. They have contributed to the development of foreign universities and have also assumed the role of training many foreign scientists and engineers.

- Other nations are advancing in terms of economic growth and technical prowess. From the viewpoint of global development and that of our own Nation, this is a positive sign. In a changing world of limited resources and increased specialization, it is becoming clear that, while striving for excellence is important, some division of labor among countries is productive. A country that increases its scientific and technical capabilities has a greater potential to solve its own problems, including those of food and energy.

National Resources for Research and Development:

- National R&D spending levels have begun to advance following a long period of reduced support.

- Basic and applied research expenditures in real dollars began to rise again in 1976. Basic research is supported primarily by Federal sources; the Government has taken the position that "prudent planning for the future demands a deliberate and continued commitment to basic research."* Applied research, supported substantially by industrial and Federal sources, also increased because of strong Federal interest and improved fiscal conditions in the private sector.

- The most dramatic change in Federal R&D spending has been in energy, which grew at an average annual rate of 33.6 percent between 1974 and 1979.

- Total national expenditures for basic research have grown during the period from 1976 to 1979 in constant dollar terms following a period of reduced spending between the late 1960's and mid-1970's.

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*Presidential Message on Science and Technology, delivered to the Congress of the United States, March 27, 1979.

- Universities and colleges now perform the largest percentage of basic research in the United States. The share accounted for by this sector has increased in recent years. In 1960 this sector spent 36 percent of the Nation's expenditures for basic research; by 1978 it had risen to 52 percent.

- Beginning in 1976, constant dollar basic research spending in industry, which accounted for approximately 16 percent of the total, has advanced slightly, following a period of declining support that began in the middle-to-late 1960's. This relatively recent, modest growth is significant because it may signal the end of the longstanding trend of decreased industrial basic research activity.

Industrial Research and Development:

- Industrial R&D expenditures from all sources were 69 percent of all U. S. R&D expenditures in 1977 and were above the low point, in constant dollars, that occurred in 1975. This return to previous high funding levels should relieve some of the concern that has been expressed about a decline in industrial R&D.

- The Federal Government's constant dollar support for R&D in industry began to increase in 1976 after reaching in 1975 its lowest level since 1964. This was largely because of increased interest in energy and in the space program. However, Federal R&D support is not expected to return soon to the high levels of the 1960's in industry.

- Company funds for R&D have increased almost every year from 1960 to 1977, at an average annual rate of 4.6 percent in constant dollars.

- About 85 percent of Federal R&D funds to industry have consistently gone to development. The share of company R&D funding going to development has risen from 66 percent in the early 1960's to 74 percent in 1977. Since the mid-1960's, there has been a drop in company support for basic research, in constant dollars, though there has been a partial recovery since 1975. Industry managers claim that the decline is due in part to a new management emphasis on shorter-term and safer investments.

Scientific and Engineering Personnel:

- Questions have recently been raised concerning a decline in the quality of the S/E work force. These questions are difficult to answer, since there are no direct measures of work force quality. However, two related measures suggest that it has not decreased: experienced S/E's continue an undiminished participation in training programs; and test scores for prospective S/E graduate students on both the verbal and quantitative components of the Graduate Record Examination remain high and unchanged, both absolutely and relative to nonscience fields.
- Although the employment of women in science and engineering has been increasing at a fairly rapid rate (12 percent between 1974 and 1976 compared to a 5 percent increase for men), women are still underrepresented in science and engineering.

- Both the number and proportion of women receiving degrees in science and engineering have increased significantly.
- Employment of minorities in science and engineering has been increasing at a faster rate than for whites. Among doctoral level S/E's, for example, employment of blacks increased by 35 percent between 1973 and 1977, while the increase for those of Asian extraction was about 70 percent. The comparable increase for whites was 26 percent.

The Role of the National Science Board

The enabling legislation of the National Science Foundation assigns policymaking functions to the National Science Board and the administration of the Foundation to the Director. The Foundation is the only Federal body which has as its broad charter responsibility for the overall health of fundamental science in the United States. The policies established by the Board on the support of science and engineering and the development of scientific manpower are implemented through the programs of the Foundation. The Board also assists in the formulation of major national science policies, particularly as they relate to the general state of science in the Nation. It initiates studies to identify promising areas of research to add to the fund of knowledge, to improve the quality of life, and to assist in the solution of national societal problems. As noted earlier, it annually assesses and reports on the status and health of science and its various disciplines.

The National Science Board includes twenty-four part-time Members, appointed by the President with the advice and consent of the U. S. Senate, and the Director of the Foundation ex officio. Recommendations for membership are sought, on behalf of the President, from the major scientific, engineering, and educational societies and associations as specified in the Act. All recommendations received from all sources are forwarded to the White House for consideration together with the joint recommendations of the Board and Director.

In formulating its recommendations, the Board considers those factors stated in Section 4(c) of the National Science Foundation Act of 1950, as amended. Professional qualifications are the primary consideration, as well as public service, geographical distribution, and balance among professional fields (including science education, law, and public affairs). Also weighed are management capability, representation of women and minority groups, and representation of various types and sizes of educational and research organizations and industry.

In addition to the recommendations made via the Board, and the joint recommendations of the Board and the Director, the President receives recommendations from members of the Congress and from other interested individuals and organizations. From this array the President then makes a selection and submits nominations to the Senate for consideration by the usual nomination procedure.

The Board is thus constituted of a wide variety of people interested in science, with a breadth of backgrounds and differences in opinion. The Members have a continuing interest in undergraduate education, since graduate education would deteriorate without good undergraduate systems. Seven past NSB Members have been from predominantly undergraduate institutions. Seven present NSB Members are from nonacademic institutions. Four, Dr. Raymond L. Bisplinghoff, Dr. Lewis M. Branscomb, Mr. Herbert D. Doan, and Dr. W. N. Hubbard, Jr., are industrial executives.

The term of office of Members is six years, expiring on May 10 of the even years. Thus terms of eight Members will expire this year. The current membership of the Board is shown in Appendix I.

The Board meets its policymaking responsibilities in a number of ways, depending largely on its committees, listed in Appendix II. It is extensively involved in long-range planning, the determination of priorities, budgeting, and the development of new programs. The process begins with identification by the Board and staff of longer term concerns which may affect many fields of science. Background information on these issues and on the anticipated future environment is prepared by NSF staff. At its June planning environment review, held under the aegis of the Planning and Policy Committee, the Board discusses such topics, formulates recommendations, and considers possible actions.

The topics considered last year by the Board included the support of young investigators and young faculty. Several possible programs were described, and the positive and negative aspects of each were discussed. The Committee on Role of NSF in Basic Research was asked to examine further these possible programs; it will provide recommendations to the Board sometime in the near future.

Consideration of another topic grew from a request to the Foundation by the House Committee on Science and Technology to reevaluate NSF research funding mechanisms. Two items in which the Committee has expressed an interest were explored in June and are now under further study: new methods of financing research equipment and mechanisms for making very small grants primarily to scientists at four-year colleges. The Ad Hoc Committee on Big and Little Science will soon bring its recommendations on these items to the Board.

Subsequently, the Board examines the scientific and program priorities of the Foundation's long-range plans and provides guidance, through the Committee on Budget, in the preparation of the multi-year cost estimates. As the Foundation's input to the President's proposed program develops, the Board keeps in close touch with events.

Status of Science Reviews--1980 provides background for the Board in its planning and budgeting activities and may also be of interest to the Congress and others considering the future of the scientific enterprise. Developed by the Board and Foundation staff, it is the latest of a series of reports summarizing the judgments of the individual NSF program directors about the current directions and opportunities in the fields of science supported through each directorate. Continuing attention is given to describing the role of the Foundation vis-a-vis other sources of support for research and science education in the Nation. The 1980 Reviews includes a new section dealing with information science and technology and applied research. A copy will be provided for the record.

Oversight of the activities of the Foundation is a major NSB responsibility. It is carried out by individual Members' activities, through the Programs Committee, as well as through the Committee on Audit and Oversight. Within the past year the latter Committee has noted that it is becoming of increasing importance to examine completed projects to determine if the results are consistent with the objectives of the program and the nature and quality of the work accomplished under the award. Experimentation with measures and mechanisms to determine this are underway within the Foundation.

Other means by which the Board discharges its oversight responsibilities include receipt of program reviews at NSB meetings, participation by the Members in site visits to the National Centers and other NSF-supported facilities and activities, and attendance at and reporting upon meetings of the NSF Advisory Council and other Foundation advisory committees.

In its report on the NSF authorization bill for fiscal year 1980, the House Committee on Science and Technology indicated that it would review the National Science Foundation Organic Act. Subsequently the Ad Hoc Committee on NSF Act Review was established to recommend to the Board its position on this matter. At the time of the initial hearings by the Subcommittee on Science, Research, and Technology in May 1979, the Board's position was that the basic concepts embodied in the NSF Act of 1950 as amended appear to be sound and that the Act needed no change.

Dr. Hubbard, Chairman of the Ad Hoc Committee, was authorized to inform the Subcommittee of the following preliminary statement of the Ad Hoc Committee:

> The mission of the Foundation, as stated in the preamble of the Act, is the continuing goal of the body of the Act as amended. The degree to which the Act provides the Foundation with authorities necessary to the fulfillment of its mission can be estimated by the adaptability of the Foundation's programs. Over time, this capacity of the Foundation for effective adaptation to change is the prerequisite for the fulfillment of its mission. These changes take place within the body of science itself; in the institutions where research and education occur; and in the problems, whose solutions include the application of scientific knowledge, that are confronted by the people of the Nation.
>
> The striking changes in the scope, content, and size of the Foundation's programs over the past ten years are interpreted by the Committee as strong inferential evidence that the Organic Act has provided sufficient authorities for effective adaptive responses in the Foundation's programs. A preliminary review of expressed concerns for both past and future programs suggests the need for a dynamic balance of valid contesting viewpoints rather than increased constraints that risk prejudging the future. At this time, the forward planning as now developed by the Foundation* is seen to be quite feasible within the terms of the Organic Act as amended.

Subsequent detailed study by the Ad Hoc Committee and extensive debate by the Board clearly showed that the NSF Act as written provides the flexibility deemed necessary by the Subcommittee, the Board and staff to carry out the general charge, as subsequently amended, to the National Science Foundation, "To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and other purposes."

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*Appendix III, NSF and Support of Research and Science Education in the 1980's (policy statement unanimously adopted by the National Science Board at its 202nd Meeting on November 16-17, 1978).

National Science Foundation Program for Fiscal Year 1981

As indicated above, the National Science Board has had a major role in the development of the Foundation's program for fiscal year 1981, the second of this new decade. Its increasing size, the second in the billion dollar range, emphasizes the investment nature of basic research and the importance of science and technology in the Nation's future. The strength and international competitiveness of the country's scientific capability must be maintained, and this program takes steps to do so.

Among the thrusts of particular interest in the program is the strengthening of basic research, with an emphasis on certain areas underlying industrial productivity and innovation, especially in the physical sciences, engineering, and computer science. A welcome associated development in the program is the effort to upgrade university research laboratories through another step-up in funds for instrumentation and inclusion of funds for refurbishing outdated facilities.

In response to a Presidential directive, the Foundation's industry/university cooperative research efforts will increase markedly to stimulate the research programs of both industry and universities. A related effort will permit strengthening small business research activities, providing the potential for an increase in their contribution to the national research effort. Another special initiative, the Ocean Margin Drilling Program (OMD), is a logical extension of the highly successful Deep Sea Drilling Project. It is an attractive convergence of scientific goals, resource exploration, and technological development, and will involve the U. S. petroleum industry. The National Science Board followed closely the development of this proposed program and believes that it can be of great scientific importance. In addition, the OMD Program will aid in the development and application of deep water technology and will be an important step in the early evaluation of continental margins as a source of hydrocarbons and other mineral accumulations. It offers new opportunities for extensive and profitable collaboration among NSF, other Federal agencies, industry, and foreign countries.

The Board strongly supports the Foundation's proposed program for fiscal year 1981 as contained in the President's Budget. It welcomes the new initiatives proposed by the President for the Foundation as an expression of his confidence in science and in the Foundation and its approaches to the Nation's problems.

* * * *

During the decade of the 1980's, through a variety of science education programs, a more scientifically-literate citizenry must develop. Society, both as a whole and as individual citizens, should expect much of science and technology, especially when supported by public funds. The individual scientist or engineer should and does expect that his or her "bit" of science, in combination with some other bits and frequently in quite unexpected ways, will through technology contribute to society. The Foundation's program for fiscal year 1981 will help make that possible.

In closing, Mr. Chairman, I would like to express my appreciation to you and the Members of this Committee for your understanding and support of science and the National Science Foundation. It has been a pleasure to work with you.

APPENDIX I

NATIONAL SCIENCE BOARD

Terms Expire May 10, 1980

DR. JEWEL PLUMMER COBB, Dean and Professor of Biology, Douglass College, Rutgers-The State University of New Jersey, New Brunswick, New Jersey 08903

*DR. NORMAN HACKERMAN (Chairman, National Science Board), President, Rice University, P. O. Box 1892, Houston, Texas 77001

DR. W. N. HUBBARD, JR., President, The Upjohn Company, Kalamazoo, Michigan 49001

DR. SAUNDERS MAC LANE, Max Mason Distinguished Service Professor of Mathematics, Department of Mathematics, Eckhart 325, University of Chicago, 5734 University Avenue, Chicago, Illinois 60637

*DR. GROVER E. MURRAY (Vice Chairman, National Science Board), University Professor, Texas Tech University and Texas Tech University School of Medicine, P. O. Box 4680, Tech Station, Lubbock, Texas 79409

DR. DONALD B. RICE, JR., President, The Rand Corporation, 1700 Main Street, Santa Monica, California 90406

DR. L. DONALD SHIELDS, President, California State University at Fullerton, Fullerton, California 92634

DR. JAMES H. ZUMBERGE, President, Southern Methodist University, Dallas, Texas 75275

Terms Expire May 10, 1982

DR. RAYMOND L. BISPLINGHOFF, Vice President for Research and Development, Tyco Laboratories, Inc., Tyco Park, Exeter, New Hampshire 03833

DR. LLOYD M. COOKE, Vice Chairman, Economic Development Council of New York City, Inc., 260 Madison Avenue, New York, New York 10016

*MR. HERBERT D. DOAN, Chairman, Doan Resources Corporation, 110 East Grove Street, Midland, Michigan 48640

DR. JOHN R. HOGNESS, President, Association for Academic Health Centers, 1901 No. Fort Myer Drive, Suite 1214, Arlington, Virginia 22209

DR. WILLIAM F. HUEG, JR., Professor of Agronomy and Deputy Vice President and Dean, Institute of Agriculture, Forestry, and Home Economics, 201 Coffey Hall, University of Minnesota, St. Paul, Minnesota 55108

*DR. MARIAN E. KOSHLAND, Professor of Bacteriology and Immunology, Department of Bacteriology and Immunology, University of California at Berkeley, Berkeley, California 94720

DR. JOSEPH M. PETTIT, President, Georgia Institute of Technology, Atlanta, Georgia 30332

DR. ALEXANDER RICH, Sedgwick Professor of Biophysics, Department of Biology, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

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*Member, Executive Committee.

Terms Expire May 10, 1984

DR. LEWIS M. BRANSCOMB, Vice President and Chief Scientist, International Business Machines, Inc., Armonk, New York 10504
DR. EUGENE H. COTA-ROBLES, Professor of Biology, Biology Board of Studies, Thimann Laboratories, University of California at Santa Cruz, Santa Cruz, California 95064
DR. ERNESTINE FRIEDL, Professor of Anthropology, Department of Anthropology, Duke University, Durham, North Carolina 27706
DR. MICHAEL KASHA, Director, Institute of Molecular Biophysics and Professor of Physical Chemistry, Florida State University, Tallahassee, Florida 32306
DR. WALTER E. MASSEY, Director, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439
DR. DAVID V. RAGONE, Dean, College of Engineering, University of Michigan, Ann Arbor, Michigan 48109
DR. EDWIN E. SALPETER, J. G. White Professor of Physical Sciences, 308 Newman Laboratory of Nuclear Studies, Cornell University, Ithaca, New York 14853
DR. CHARLES P. SLICHTER, Professor of Physics, Room 311, Loomis Laboratory of Physics, University of Illinois, Urbana, Illinois 61801

Member Ex Officio

*DR. RICHARD C. ATKINSON (Chairman, Executive Committee), Director, National Science Foundation, Washington, D. C. 20550

* * *

MISS VERNICE ANDERSON, Executive Secretary,
National Science Board, National Science
Foundation, Washington, D. C. 20550

September 21, 1979

APPENDIX II
January 1986

NATIONAL SCIENCE BOARD
COMMITTEE STRUCTURE AND MEMBERSHIP

The National Science Foundation Act assigns policymaking functions to the National Science Board and the administration of the Foundation to the Director. The Board's policymaking responsibilities are met initially through the work of its committees.

Except for the Executive Committee, which is a statutory committee, the National Science Board and its Chairman establish the committees of the Board and make appointments to them. At each annual meeting the Board reviews the committee structure and the continuation of the task and ad hoc committees.

Board committees fall into four categories: statutory, standing, task, and ad hoc. The functions of the committees consist of a series of initial charges and such variations as are deemed desirable and useful once the committees are in operation.

The functions and chairmanship of the current Board committees are given below:

A. STATUTORY COMMITTEE

Section 6(a) of the National Science Foundation Act, as amended, states that:

> "There shall be an Executive Committee of the Board (referred to in this Act as the 'Executive Committee'), which shall be composed of five members and shall exercise such powers and functions as may be delegated to it by the Board. Four of the members shall be elected as provided in subsection (b), and the Director ex officio shall be the fifth member and the chairman of the Executive Committee."

The Executive Committee has the following responsibilities:

- Fulfills statutory functions: (1) exercises such powers and functions as may be delegated to it by the Board, and (2) renders an annual report to the Board, and such other reports as it may deem necessary, summarizing its activities and making such recommendations as it may deem appropriate. Minority views and recommendations, if any, of members of the Executive Committee are included in such reports.

- Acts on behalf of the Board between meetings on (1) grants, contracts, or other arrangements; and (2) other instances where immediate decision is required. (All such actions are reported to the Board at its next meeting.)

- Considers and approves affiliations of the Director, Deputy Director, and Assistant Directors.

- Coordinates and offers guidance on activities of the Board and its committees.

- Serves as agenda committee for the Board.

- Identifies subjects to be considered by task and ad hoc committees.

B. STANDING COMMITTEES

The standing committees of the Board are continuing committees with definite responsibilities to perform assigned tasks and to present recommendations to the Board. All Members who are not on the Executive Committee are assigned to one of the two standing committees, the Planning and Policy Committee and the Programs Committee.

1. The responsibilities of the Planning and Policy Committee (Dr. W. N. Hubbard, Jr., Chairman, and Dr. Raymond L. Bisplinghoff, Vice Chairman) are as follows:

- Considers policy issues and prepares draft documents including "white papers" on principal planning and policy issues affecting research and science education for subsequent Board consideration.

- Identifies and recommends actions for the Board with regard to policies and practices affecting research and science education in the Nation with particular attention to NSF.

- Develops and coordinates the long-range planning meetings of the Board, and all associated documentation through interaction with NSF staff.

- Identifies national science policy issues and national needs and considers the proper roles of the Federal Government in general and NSF in particular.

- Meets with the Committee on Budget to coordinate planning, policy, and budget processes.

The Planning and Policy Committee has two subcommittees: the Subcommittee on International Science Activities, chaired by Dr. Jewel Plummer Cobb; and the Subcommittee on Science and Society, chaired by Dr. Eugene H. Cota-Robles.

2. The major activities of the Programs Committee (Dr. L. Donald Shields, Chairman, and Dr. Saunders Mac Lane, Vice Chairman) are as follows:

- Reviews proposed programs and makes recommendations to the Board.
- Reviews all proposals for support containing new policy issues or over certain dollar amounts prior to presentation to the Board with Committee recommendations.
- Monitors existing programs and activities.
- Maintains oversight on long-term commitments of the Foundation.
- Schedules formal and informal reviews of programs, especially for input to discussion of the planning environment review document at the long-range planning meetings.

C. TASK COMMITTEES

The task committees of the Board are assigned specified tasks which are sometimes of a short-term nature. These Committees are discharged upon completion of these assigned tasks. The one exception is the Committee on Budget which is an ongoing committee.

1. The Committee on Audit and Oversight, chaired by Dr. Lloyd M. Cooke, reviews the requirements for continued functioning of the Action Review Boards and the effectiveness of other oversight mechanisms.

2. The Committee on Budget (Dr. Marian E. Koshland, Chairman, and Dr. Donald B. Rice, Jr., Vice Chairman):

- Provides a focal point for Board participation in budgetary matters, including program priorities.
- Provides advice to the Board on NSF authorization and appropriation issues.
- Helps serve as spokesmen for the Board on NSF budgetary matters with the Congress and the Office of Management and Budget.
- Reexamines priority considerations, based on results of the long-range planning meetings, to integrate (a) immediate priorities into summer and fall budget preparation, and (b) deferred program priorities into fall preparation of long-range planning estimates.

- Meets with Planning and Policy Committee to review results of Board discussion of and actions/guidelines on the planning environment review document for long-range planning meetings.

3. The Committee on Minorities and Women in Science, chaired by Dr. Jewel Plummer Cobb, considers education and research programs to increase the flow into science of (a) ethnic minorities, (b) women, (c) the disadvantaged, and (d) the physically handicapped.

4. The Committee on Role of NSF in Basic Research is chaired by Dr. Alexander Rich. It:

- Monitors NSF's role in support of basic research in the natural and social sciences.

- Examines factors affecting the quality and quantity of basic research being performed and identifies problem areas and adverse trends.

- Formulates mechanisms for Board consideration which will contribute to the general health of basic research.

5. The Committee on Twelfth NSB Report (Dr. John R. Hogness, Chairman, and Dr. Lloyd M. Cooke, Vice Chairman) provides oversight on preparation of the report to the President and the Congress, due March 1980, on the impact of research upon the general welfare.

6. The Committee on Thirteenth NSB Report (Dr. Joseph M. Pettit, Chairman, and Dr. Eugene H. Cota-Robles, Vice Chairman) provides oversight on preparation of Science Indicators--1980, due March 1981.

7. The Committee on Fourteenth NSB Report (Mr. Herbert D. Doan, Chairman, and Dr. Walter E. Massey, Vice Chairman) provides oversight on preparation of the report to the President and the Congress, due March 1982.

D. AD HOC COMMITTEES

Ad Hoc Committees of the Board have specific tasks generally of short duration.

1. The Ad Hoc Committee on Big and Little Science, chaired by Mr. Herbert D. Doan, continues the consideration of the overall Foundation policy on "big" and "little" science and presents recommendations for the Board's approval.

2. The Ad Hoc Committee on Deep Sea and Ocean Margin Drilling Programs, chaired by Dr. Raymond L. Bisplinghoff, monitors and informs the Board of developments regarding the future drilling programs, both in terms of the alternatives that are being considered, the costs, and how those costs might be shared among agencies of the U. S. Federal Government, foreign countries, or other groups.

APPENDIX III

January 1979

NSF AND SUPPORT OF RESEARCH AND SCIENCE EDUCATION IN THE 1980'S
POLICY STATEMENT UNANIMOUSLY ADOPTED BY THE NATIONAL SCIENCE BOARD AT ITS 202ND MEETING ON NOVEMBER 16-17, 1978

AGENCY MISSION

The fundamental purpose of the National Science Foundation is to benefit the general welfare by fostering creativity in the pursuit of basic scientific understanding.

This fundamental purpose is enabled by support of:

1. Basic research in the physical, mathematical, biological, social, and other sciences and in engineering;
2. Science education and training to develop new scientific talent;
3. Applied research that links and develops knowledge in ways that enhance its usefulness;
4. Selected activities to improve the understanding of science and its use by all students and by the public;
5. Research resources (facilities) and institutional forms required in the conduct of research.

AGENCY GOALS

The goals of the National Science Foundation are to:

1. SUPPORT RESEARCH on (a) fundamental laws of nature, (b) man and his natural and social environment, and (c) technology-oriented sciences.

    - Provide SUPPORT to the highest quality researchers in areas with significant potential for advancing scientific understanding.

- Provide RESEARCH RESOURCES AND EQUIPMENT demanded in the conduct of science.
- Foster EDUCATION AND TRAINING to maintain U.S. scientific leadership in future generations.

2. ENHANCE RETURNS FROM NATIONAL INVESTMENT IN BASIC RESEARCH.
    - Encourage development in those areas of science with EXCEPTIONAL PROMISE for contributing to resolution of significant problems.
    - Foster greater COOPERATION within national and international communities.
3. IDENTIFY AND RECOMMEND NATIONAL POLICIES DESIGNED TO ENHANCE THE HEALTH AND VIGOR OF THE NATION'S SCIENTIFIC ENTERPRISE.
    - Provide INFORMATION AND ANALYSIS regarding national Science and Technology capabilities.
    - Recommend POLICIES designed to maintain a strong national research capacity.
4. MAINTAIN AND IMPROVE AGENCY EFFECTIVENESS AND RESPONSIVENESS.
    - Encourage EQUAL OPPORTUNITY for participation in science.
    - Foster greater PUBLIC UNDERSTANDING of science and the impact of science on public policy issues.
    - Improve AGENCY MANAGEMENT and ACCOUNTABILITY.

The CHAIRMAN. Dr. Ernest Ambler, from the National Bureau of Standards.

[A biographical sketch of Dr. Ambler follows:]

DR. ERNEST AMBLER

Dr. Ernest Ambler has served with the Federal Government since 1953 when he joined the staff of the National Bureau of Standards. In 1973, he was appointed Deputy Director of that organization and has been serving as Acting Director since the resignation of Dr. Richard W. Roberts in June 1975.

Throughout his career, Dr. Ambler has worked to make NBS an increasingly valuable scientific and technical resource for industry, business, Government, education, and the public. As a scientist, he has contributed directly to the state-of-the-art in measurement technology. His expertise in nuclear physics and cryogenics formed the basis in 1956 for a cooperative effort that disproved the law of parity conservation, a concept that nuclear scientists had adhered to for more than 30 years. This pioneering project confirmed experimentally the theoretical work of Nobel Prize winners T. D. Lee and C. N. Yang.

As an administrator, Dr. Ambler has helped guide Bureau operations and policies to improve the efficiency with which NBS fulfills its mission. His management responsibilities began in 1961 when he became Chief of the Cryogenic Physics Section. Four years later, he was appointed Chief of the Inorganic Materials Division in 1968, as Director of the Institute for Basic Standards, he assumed responsibility for directing the most basic NBS research activities, developing and maintaining standard and measurement techniques for such quantities as length, mass, time and frequency, and temperature.

Among Dr. Ambler's continuing concerns is the Bureau's role in international science. He has long acknowledged that through its mission and diversity, the Bureau can act as a prime agent in international scientific cooperation and can support U.S. foreign commerce through participation in international standardization activities. In 1972, Dr. Ambler was elected to serve as the U.S. representative to the International Committee of Weights and Measures (CIM), the executive body of the General Conference of Weights and Measures, in addition, he serves as Chairman of the Consultative Committee on Standards for Measuring Ionizing Radiations of the CIPM.

Dr. Ambler is the recipient of numerous awards and fellowships: including The Department of Commerce Gold Medal, the NBS Stratton Award, Nuffield Fellow of Oxford University, the John Simon Guggenheim Memorial Foundation Fellowship Award, the John Price Wetherill Medal of the Franklin Institute, the Washington Academy of Science Award, the Arthur S. Flemming Award, the William A. Wildhack Award, and the President's Award for Distinguished Federal Civilian Service. He has authored 51 publications and holds a patent for low temperature refrigeration apparatus and processes.

Born in Bradford, Yorkshire, England, in 1923, Dr. Ambler earned his B.A., M.A. and PhD. in physics at Oxford University before coming to the National Bureau of Standards. He became a United States citizen in 1958. Dr. Ambler and his wife, Alice Seiler Ambler, a former staff member in the NBS Heat and Building Research Division, were married in 1955. They live in Bethesda, Maryland, with their two sons, Christopher and Jonathan.

STATEMENT OF DR. ERNEST AMBLER, DIRECTOR, NATIONAL BUREAU OF STANDARDS

Dr. AMBLER. Thank you, sir.

Mr. Chairman and members of the committee, I am very pleased to be invited here today to discuss what we at the National Bureau of Standards believe will be the broad trends in science and technology and their impacts during the 1980's. I will suggest some strategies that we believe can improve the effectiveness of our R. & D. efforts. I will also describe the Bureau's current R. & D. functions and how we anticipate they will develop and contribute to a strong and adequate posture for American science and technology in this decade.

It is now clear that the U.S. advantage in abundant raw materials and cheap energy is gone. The U.S. share of the world market is declining. Concurrently, on a world basis the U.S. share of investments in R. & D. is falling. These are trends that began a long time ago, after World War II, when many nations began to recover from technical industrial positions well behind those of the United States. These nations have rebuilt their manufacturing plants; they have supported industrial research and development at an increasing rate; and some have, as a matter of national policy, targeted U.S. markets for penetration. These are inevitable trends and are a result of the economic recovery that has taken place in many countries, to which the U.S. contributed as a matter of national policy.

The success of U.S. industries in the world marketplace is becoming increasingly dependent on R. & D. based high-technology products. Department of Commerce data show that between 1960 and 1977 the U.S. trade balance in R. & D. intensive products grew from a surplus of $6 billion to a surplus of $28 billion, while the balance in non-R. & D.-intensive products declined from an even position to a deficit of $24 billion. To me these are very revealing numbers. There are also many other relevant statistics relating to productivity growth rates, rates of capital formation and investment in R. & D., which point up the need for U.S. response. I will leave analyses of these data to others and confine myself to observations I can make as a laboratory director.

U.S. technological and industrial leadership is necessary for a vigorous economy and for our survival and competitiveness in international affairs. We have the capacity for such leadership. In spite of the trends I mentioned earlier, our research establishment, as Dr. Hackerman indicated, is still the best in the world and our work force is still the most productive. There are, however, a number of R. & D. strategies which I believe should be followed to improve our productivity.

First, we must strive for the best; first-class scientific research is far better than second-class, and it produces far superior technology. Research institutions must have special concern for those individuals who provide intellectual leadership and who inspire the whole organization by their ability to compete in the world arena. Certainly, there should always be long-range projects whose investigators have considerable scientific freedom.

Second, equipment is an increasingly important and expensive ingredient in successful R. & D. Therefore, it is necessary to provide the best equipment, to manage it wisely, and to make it available across organizational lines. Some equipment is becoming so expensive that it must be shared between institutions—and indeed between countries.

Next, in order to maximize our return on investment in R. & D., we need to foster closer cooperation between industry, government, and academia. This is particularly true in areas of basic engineering and generic technology that underlie and provide a fertile base from which ideas and inventions spring for new products and processes.

Finally, we should clearly focus our R. & D. efforts. This focus must be on areas of science and technological opportunity and on urgent national problems.

Before citing specific opportunities, I would like to mention three research trends cited in the recent National Research Council publication "Science and Technology—A 5-year Outlook." First, many opportunities exist at the interfaces between traditional disciplines, and I think Dr. Atkinson referred to that. Second, mathematical modelling and the theory of scaling will become increasingly important tools. Finally, accurate measurement will become increasingly important as we emphasize the need for precise and quantitative information.

In the category of opportunity, the 1980's will see a continuation of the electronics, computer, and telecommunications revolution. Future advances will result from breakthroughs in the application of fundamental knowledge, and from development of ever more sophisticated production techniques. The practical consequences will be an acceleration of the already rapid extension of computers and microprocessors into almost every aspect of American life. The hardware revolution is well underway. It should be fostered. However, the opportunities offered by lowered hardware costs will be fully exploited only when coupled hardware/software systems perform correctly, are reliable, and cause no unacceptable harm when they fail. We must improve techniques for the production of validated software.

The next decade should see the rapid application of industrial automation. For example, automation of batch manufacturing can dramatically increase production through more flexible use of machinery and lower rejection rates. The design process will also be influenced by the use of computers. Quality control will involve measurements that are made automatically, with the results fed back to control and correct the manufacturing process.

There are broad opportunities in the materials area. New measurement techniques, data, and theories will lead to creation of materials having high strength, low weight, better corrosion resistance, better formability, and so on. With new theoretical developments, it will be possible to predict with confidence the performance and durabality of materials and to design safer, longer lasting structures.

There will be an accelerating effort to develop and commercialize new energy sources. The rate of commercialization will be driven by increases in oil prices on the one hand, and by developments in technology on the other. These advances will be paralleled by intensive conservation efforts.

In the area of regulation, a new philosophy has found its way into law; namely, regulation at the source. This approach requires strict accountability by the producer for chemical products and their potential fate in the environment. Such accountability requires better measurements, better modelling capabilities, and better data on chemical reactions under various environmental conditions.

I will now mention the Bureau's current and future work and illustrate how we employ the four R. & D. strategies I have described. In the time available I cannot be comprehensive, so I hope you will view what I have to say as illustrative. There will be an opportunity to testify in depth at the upcoming authorization hearings.

First, in the area of research quality, we began, in fiscal year 1979, a program called "competence building." This program will develop and support individuals or groups for work in world-competitive frontier research consonant with the NBS mission and essential for meeting future demands.

Second, for the past 6 years the administration and Congress have supported an equipment modernization program for NBS which has had an extremely positive influence on the quality and scope of NBS science and engineering. We are managing the use of this equipment across organizational lines, and we are beginning to make greater use of outside facilities. For example, in cooperation with the Naval Research Laboratory, NBS is establishing an X-ray beam line at the Brookhaven National Synchroton Light Source, principally to do materials research.

Third, with regard to interaction and cooperation with government, industry and academia, NBS is a particularly good case study. To assure that our programs and services are relevant, approximately 235 prominent outside scientists and engineers formally review NBS plans and progress each year. Our Statutory Visiting Committee, consisting of five of the Nation's leaders in science and technology, also assesses our program and reports to the Secretary of Commerce each year.

In addition, NBS has a multiplicity of arrangements for collaborative research. For example, 29 companies and trade associations currently support 95 scientists and engineers on joint programs at NBS. With academia, we have 51 cooperative educational agreements, 190 university guest scientists, and 40 postdoctoral fellows. And there are 34 intergovernmental personnel exchange representatives at NBS at the present time.

Under the standard reference data program, the NBS operates 22 data centers, many in universities, which disseminate critically evaluated data. We collaborate in standardsmaking by holding some 1,400 positions on joint standards committees, and we hold NBS symposia and workshops having an annual attendance in excess of 16,000.

Each year NBS provides technical support to more than 100 Federal agencies. Over the years, the Department of Defense has been a major client. In recent years the Departments of Energy, Health, Education, and Welfare, Housing and Urban Development, Transportation, the Consumer Product Safety Commission, NASA, and the Nuclear Regulatory Commission have become major users of NBS services. In sum, NBS work involves many partners, and thus it has a pervasive effect throughout society.

Now I will turn to NBS programs in the specific areas of science and technology opportunity and national problems I mentioned earlier.

As the semiconductor industry and its support industries have grown during the past decade, NBS has met their needs for consistent measurements and reference materials. The current trend to very large-scale integration has created measurement requirements for extreme precision and sensitivity. NBS is working to develop technology and techniques to meet these needs and which will be practical in the production environment. Recently NBS has carried out pioneering investigations of low-dose ion implants in silicon wafers by using laser annealing to remove process-induced damage. Our work on optical methods for measuring photomask linewidth has led to a new calibration service. Current tasks involve resolution of the discrepancies between electrical and optical properties of deep impurity levels in semiconductors; development of methods for testing integrated circuits through the use of large area test structures; and extension of microelectronic test structures to submicrometer geometries.

Turning to automation, our work in analyzing standards that pertain to the use of computers in manufacturing has been hailed by industry. NBS is leading an industry-Government program to develop an initial specification for the exchange of geometric information among computer-aided design and manufacturing systems. We are also developing a common numerical-control manufacturing data package. To enhance the quality of finished products without increasing the labor content of the process, emphasis is shifting in the direction of dynamic, online measurement for inspection and control. NBS work in this area couples more capable sensors with real time computer control of the process.

The need to create new materials tailored for specific applications is growing. Doing so requires the ability to measure composition and microstructure on an ever finer scale. The NBS materials program is aimed, in part, at this requirement. For example, a new scanning transmission electron microscope now on order will provide access to compositional and structural information nearly at the molecular level. We are developing our small angle neutron scattering capability that will enable us to determine the location and motion of atoms at a level of detail that was previously unattainable. The X-ray facility at the National Synchroton Light Source at the Brookhaven National Laboratory that I mentioned earlier will permit us to observe crack growth, to observe crystal structure during solidification, and to study the interface between the metal and the passive film that protects it from corrosion.

In areas critical to the Nation, such as energy conversion and energy conservation, NBS actively cooperates on national programs with the Departments of Energy, Housing and Urban Development, the General Services Administration and the Nuclear Regulatory Commission in providing needed information. We support the chemical process and gaseous fuel industries with critically evaluated data on the chemical kinetics, thermodynamics, phase equilibria, and transport properties of such fluid mixtures as liquefied natural gas. We have a very active program in determining the erosion and corrosion resistance of ceramic materials and metals used in the very hostile environments that exist in coal conversion systems. In collaboration with the Department of Energy, we are developing plasma diagnostics for the accurate determination of temperatures in Tokamak fusion energy systems.

Turning to conservation, NBS is developing test methods for low-density, thick insulating materials, and performance criteria for innovative building components. We also maintain the most comprehensive computer-based model for assessment of the thermal and energy performance of buildings.

In the coming decade the Bureau will provide the measurement science, mathematical modeling and statistical analysis needed as a basis for rational and equitable regulation. In the past, the NBS program in support of regulatory activities in the environmental area was primarily concerned with accurate measurement of pollutants already in the environment. Now, the Toxic Substances Control Act is forcing entirely different approach to regulation, in that regulation must be accomplished before new chemicals are introduced into the environment. Thus, NBS must develop quality control techniques and standards for the measurement of physical and chemical properties for generic types of compounds representative of industrial products.

I indicated earlier that there was a need to attack fruitful areas of research through multidisciplinary efforts. Let me give you just one example. In fire research, the development of tools for mathematical prediction of the growth of room fires is of the highest importance if the Nation is to reduce the loss of lives and property in fires. To address this problem, NBS has brought together its expertise in applied mathematics, statistics, chemistry, fluid mechanics, gas and particulate sciences, computer sciences, and fire sciences. The resulting multidisciplinary effort has already attracted worldwide attention.

So far I have indicated some of the things that NBS is planning to do in response to broad trends in science and technology. But carrying out the unique role of NBS as the Nation's central reference laboratory will always be the first priority activity for us. This is particularly true with regard to determination and measurement of the base physical quantities such as time, temperature, length, mass, electric current and luminous intensity.

In addition to maintaining and improving standards, NBS is constantly seeking better ways to disseminate its results to achieve measurement accuracy in the field. Since its inception, the Bureau has provided calibration to industry, other Federal agencies, and State and local governments. In our calibration services, we measure the difference between devices sent to us and our own standards of known accuracy. However, calibration of an instrument does not insure the accuracy of measurements made in the user's own facility. In response, NBS is developing, with the cooperation of users, a service called measurement assurance programs, MAP. In a measurement assurance program, NBS provides a procedure by which the user may continuously demonstrate the real performance of his entire measurement system including methods, operation, equipment, environment, et cetera.

Another central feature of our measurement services is our standard reference materials program. Standard reference materials are materials whose physical or chemical properties are certified by NBS for use in outside laboratories to check the accuracy of measurement devices and techniques. More than 80 percent of the 40,000 standard reference materials we sell each year are used by industry. In fiscal year 1979, NBS sold standard reference materials to 83 of the 100 largest industrial corporations in the United States, and to more than 10,000 other firms worldwide.

Mr. Chairman, I have tried to be responsive to your question. As a Nation we are in an increasingly competitive situation with regard to R. & D., but I believe that we have the means for competing successfully. I am as optimistic about future opportunities for the country as I am about NBS. The administration supports a strong and vigorous NBS and so does our Statutory Visiting Committee. Our programs are getting more attention, visibility, and support, and that is good.

I certainly appreciate the active interest shown by this committee in its invitation to testify today and in making NBS a part of the regular authorization process, to which these hearings are an introduction.

If I may add just a word to what Mr. Brown mentioned earlier, we do extend a very cordial invitation to all members of the committee to attend the Bureau on Friday, when the first of our authorization hearings will be held in our Red auditorium.

Thank you, Mr. Chairman. I will be pleased to answer questions that you have.

The CHAIRMAN. Thank you, Mr. Ambler.

[NBS statement of fiscal year 1981 Budget Request follows:]

UNITED STATES DEPARTMENT OF
COMMERCE
NEWS
WASHINGTON, D.C. 20230

NATIONAL
BUREAU OF
STANDARDS
Washington, D.C. 20234

HOLD FOR RELEASE UNTIL
10:00 a.m. January 28, 1980

Mat Heyman
301/921-3181

80-2

STATEMENT OF FY 1981 BUDGET REQUEST

A total of $107,869,000 is included for the Commerce Department's National Bureau of Standards (NBS) in the Fiscal Year 1981 budget proposal sent to Congress today by President Carter.

The budget request represents an increase of $12,531,000 and is 13.2 percent above the FY 1980 appropriation and pending pay raise supplemental. This includes $11,049,000 for program changes and new initiatives.

Included in the FY 1981 request are major increases for research on very large scale integrated circuits and for a program begun two years ago to enhance the scientific competence of NBS.

A package of basic research proposals amounting to $5 million is also included. This request has been included with the specific endorsement of the President's Office of Science and Technology Policy. The proposal reflects the Administration's interest and concern in supporting basic research in the Federal government.

Other program increases would permit NBS to meet the most urgent computing requirements of the Bureau and allow certain facilities to be modified.

"This budget request would allow us to build upon actions taken in recent years to strengthen NBS and permit Bureau resources to be used in

- more -

the most responsible way in dealing with national problems," said NBS Director Ernest Ambler. "The continued funding to enhance NBS scientific competence and the special package of basic research proposals, in particular, would help ensure that the Bureau can anticipate and meet future scientific and technological needs of our Nation." Ambler noted.

A description and breakdown of the FY 1981 budget request for NBS is attached.

BREAKDOWN OF NATIONAL BUREAU OF STANDARDS FY 1981 BUDGET REQUEST

The National Bureau of Standards (NBS) budget request for FY 1981 is a total of $107,869,000, which includes an increase of $12,591,000 above the FY 1980 appropriation and pending pay raise supplemental. A total of $11,049,000 is included for program changes and new initiatives, with the remainder of the increase taking into account inflationary adjustments.

Very Large Scale Integrated Circuits

A total of $3.3 million for very large scale integrated (VLSI) Circuits. This proposed increase would allow NBS to develop the widely needed test procedures and measurement techniques to be used by the semiconductor industry to meet the increasing quality control demands associated with the manufacture of VLSI circuits. The NBS research effort, focused on measurement science, is expected to have a substantial impact on improving the yield of good circuits by enabling the manufacturers to better control the numerous processes used in making VLSI circiuts. In addition, the measurements and procedures developed by this effort will provide a uniform basis upon which decisions can be made to buy and sell semiconductor materials, manufacturing equipment, and completed circuits in both domestic and foreign markets.

Competence Enhancement and Basic Research Package

A total of $2 million in the area of central technical support to continue a program to enhance the scientific competence of NBS. Begun two years ago, this effort is directed at strengthening the technical capabilities of NBS, allowing NBS to attract top scientific talent and permitting researchers an opportunity to explore the fundamental questions which will have great practical significance in the coming decades.

The largest single increase in the proposed budget is $5 million for a package of basic research proposals. Eight research areas have been selected to receive this additional funding:

Intrinsic transport standards ($500,000). Theory and methodology will be developed for intrinsically accurate portable standards for incorporation in instruments designed for field use. These standards will enhance the reliability, efficiency, and independence of industrial and scientific measurements.

Time-Resolved Measurements of Thermodynamic Variables ($500,000). Physical principles, signal sources, and detectors for accurate, very rapid measurements of industrially important variables will be developed. This research will lead to greater efficiency in many complex industrial processing systems.

Quantitative Compositional Mapping ($400,000). This research will enable NBS to develop analytical techniques and the scientific basis required for quantitative measurements of the chemical composition of particles and high technology materials.

Basic Metallurgy and Materials Science Research ($2,000,000). These funds will permit NBS to develop models which predict the relationship between alloy microstructure and process variables such as temperature, mechanical stresses and composition. This research will provide industry with the scientific basis for the significant development of innovative metals processing techniques.

Real-time Topography Facilities and Research ($300,000). An experimental setup will be developed as an initial step for undertaking research in real-time crack growth, phase transition, and corrosion studies. This research will lead to major advances in materials science.

Relativistic Effects in Atomic and Molecular Interaction ($400,000). NBS will develop methods of known accuracy for predictive basic atomic and molecular data of chemical systems.

Testing Strategies for Complex Electronic Systems ($400,000). This research will permit NBS to develop the fundamental knowledge needed in the evaluation of testing strategies for complex electronic systems. Work in this area will assure the highest performance of automatic test equipment during the available test time.

Metrology for Electronic and Optical Gigabit Signal Processing ($500,000). This involves the development of the basic science needed to investigate limits to the speed and accuracy of signal processing and signal measurements. This research is significant for the information processing of complex systems, which is emerging as a new branch of science and engineering.

Other Increases

Several other NBS programs would receive increases in the FY 1981 budget. Other increases include:

A total of $1 million for computing services. This will permit NBS to meet the most urgent current computing requirements.

A total of $.4 million for facilities modification. This funding will permit modifications which will give the handicapped greater access to NBS facilities in Gaithersburg and Boulder. It will also begin a long-term program to replace aging plant equipment.

ESTIMATED NBS OPERATING FUNDS

(Congress only)*

(in millions of dollars)**

	FY79 (actual)	FY80*** (estimate)	FY81 (request)
Measurement research and standards:			
Physical and chemical measurements and standards	$17.27	16.64	19.01
Materials and thermodynamics measurements and standards	14.87	16.38	20.10
Measurement assurance program	2.12	2.53	2.68
Applied measurement program	8.44	9.22	9.73
Subtotal	42.70	44.76	51.51
Engineering measurements and standards:			
Engineering standards	2.22	1.49	1.61
Safety and performance engineering research	5.14	4.78	5.09
Technical support to industrial productivity	15.26	13.18	17.51
Mathematical science	2.80	2.82	3.01
Fire science and engineering	----	1.14	1.25
Subtotal	25.41	23.42	28.47
Computer sciences and technology	11.28	11.23	11.60
Cooperative technology	1.58	----	----
Central technical support:			
Maintenance of technical competence	4.63	8.14	11.40
Capital transfers and facilities	.20	.20	.56
Subtotal	4.83	8.34	11.97
Transfer to working capital fund	3.33	4.84	4.32
TOTAL	89.13	92.58	107.87

*NBS receives additional funding from other Federal agencies and the private sector for research and services provided.

**All figures may not add due to rounding.

***Excludes pending pay raise supplemental of $2.7 million.

Funding Decrease

One funding decrease is included in the FY 1981 budget proposal. The Field Methods program, which includes the Experimental Technology Incentives Program (ETIP), would curtail policy experiments by $574,000. This program will be refocused to ensure that the results of past studies are incorporated into the appropriate government policies and regulations before new studies are undertaken. The impact of this reduction will be minimized since various related activities are included in the Department's industrial innovation programs.

The Chairman. Mr. Macy, the Director of the Federal Emergency Management Agency.

STATEMENT OF JOHN W. MACY, JR., DIRECTOR, FEDERAL EMERGENCY MANAGEMENT AGENCY

Mr. Macy. Thank you, Mr. Chairman. I appreciate the opportunity to join with you and the members of the committee in this posture hearing.

The Chairman. I think this is the first time that FEMA has testified before this committee.

Mr. Macy. That's right. This is my maiden voyage, Mr. Chairman, and this is the newest of the ships on the Federal sea. Also, this will be one of our first tests of our seaworthiness in dealing with the science and technological issues that are of interest to this committee. I am particularly pleased to be associated in offering this testimony with Dr. Atkinson, Dr. Hackerman, and Dr. Ambler, all of whom have provided a most appropriate backdrop for the description of the science and technological interests of the Federal Emergency Management Agency.

I would like to file, with your permission, Mr. Chairman, a 23-page statement that I have prepared, which was presented to the committee earlier, and then to highlight the points in that testimony in order to conserve time and to permit questions which I'm sure you and the other members of the committee may have.

The Chairman. Yes. We will make it part of the record in its entirety.

Mr. Macy. The Federal Emergency Management Agency was created by the President's Reorganization Plan No. 3 in 1978. The agency came into being by Executive Order on April 1 of last year, and the various activities transferred to it joined to form the agency on July 15. I became Director by nomination from the President and confirmation by the Senate on August 1. So we have had several months in which to bring together the agencies that were transferred to form this new governmental institution to deal with the full range of emergency management responsibilities in the executive branch.

The agency was composed by the transfer of five different agencies that had functioned in other organizational locations within the executive branch. They have been absorbed into the Federal Emergency Management Agency and form elements in the development of this new institution, which has the broad charter of planning, preparing, responding, assisting recovery, and mitigation of a broad range of risks, hazards, and emergencies that face the American public across the land.

In order to carry out that broad mandate, the agency has been organized into six major programs.

The first program is that of plans and preparedness. This is the functional area of developing plans to meet the broad range of emergencies that spread from the holocaust of nuclear attack to manmade and natural disasters which have high frequency. The planning and preparedness activities cover that range and are designed not only to provide guidance in the event of those emergencies but to provide the means for testing those plans in order to confirm or correct their validity.

The second area is that of the disaster response and recovery program. This particular segment of the agency administers the disaster assistance legislation passed a number of years ago. It is the agency that comes into action when the President declares a disaster for a given area, in response to requests from State Governors. It is this organization that becomes the Federal coordinator in each of those emergencies and is concerned in working with the States, the local officials, and with the private sector in responding to the conditions of the disaster and facilitating the recovery from it.

The third area is that of training and education. In view of the fact that the programs of the agency are directed to assist State and local authorities, the training and education program is intended to assist in increasing the capacity of all levels of government to respond to emergencies of all kinds.

An agency that is familiar to you in this committee is the U.S. Fire Administration, and this has been transferred intact to the Federal Emergency Management Agency and will continue its four-pronged program in education, training, data collection, and analysis, and in research.

The fifth agency is the Federal Insurance Agency, which was transferred from Housing and Urban Development, and is concerned with programs that relate to flood, crime, and riot insurance.

The sixth program is the one on which I want to focus my attention. That's the program, or the organization, of mitigation and research. This particular organization was identified as a separate responsibility, the belief being that if that were not so the research activities would tend, in an organization of this kind, to be obscured or submerged by the operational activities in other parts of the organization, and so this is a separate element and one that is headed by an Associate Director of the Agency, Richard Greene, a distinguished Government science administrator, who is bringing together the various research programs inherited from the other agencies, as well as charting a course for research and development under the new agency.

I think it's important to emphasize, Mr. Chairman, that in performing this mitigation and research responsibility the Federal Emergency Management Agency is not undertaking a research program of its own, that its function is primarly that of coordinating and interrelating various research and development activities performed elsewhere in the Federal Government and to assist in the application of the scientific and technological results of those efforts into various aspects of emergency management. The belief is that there can be a more significant application of technological progress to meeting the needs of emergencies in this country, emergencies over the entire scope that I mentioned earlier.

In order to organize the activities in the mitigation and research area, we have designated four program areas.

The first is that of applications. This is the outreach effort of our organization. This is the organizational means by which we attempt to reach the other departments and agencies with research responsibility. It is our effort to communicate the requirements for research to scientific institutions in the private sector. This is the point at which we intend to bring together information that relates to scientific applications to emergency management.

The second area is that of natural and technological hazards. This is an effort to identify the various causes of emergencies, whether they be waterborne or airborne or whether they are reflected in earthquakes, or hurricanes, or tornadoes, or other natural phenomena, or, on the technological side, the emergencies that occur as a result of explosions, or major industrial fires, or other difficulties of that nature.

The third area is that of national security, and this ties to the previous efforts in civil defense and in defense mobilization. These are areas of research that give us indications as to materials and designs that are to be most effective in meeting the possibility of nuclear attack.

The fourth area is that of systems analysis and integration. This is an effort to interrelate the various disciplines and processes that relate to emergencies of all kinds.

In your invitation to the hearing, Mr. Chairman, you asked that there be specific reference to the earthquake program and to the fire research program.

As far as the earthquake activity is concerned, it has been transferred to FEMA from the Office of Science and Technology Policy as of July 15 of last year, and it is now the responsibility of FEMA as the lead agency to carry out the program of 1978 that was embodied in Public Law 95–124. The functions of the lead agency involve the coordination of the Federal departments and agencies that have areas of responsibility with respect to earthquake and seismic phenomena.

We have heard reference to the work sponsored by the National Science Foundation, and work being pursued by the National Bureau of Standards. There are other agencies, such as the U.S. Geological Survey, that are also engaged in this kind of research.

The second function is to provide leadership and support for the Federal Interagency Committee on Seismic Safety in Construction. This is a specific institution that has been established as a means whereby there can be greater interagency collaboration in providing seismic safety information for construction.

The third area is that of the appropriate role for insurance in connection with earthquakes, and this relates very closely to the Federal Insurance Administration, which is a part of this agency.

Fourth, to work with States and municipalities in the development of plans to deal with earthquake conditions as they arise.

In the incidence of earthquakes we have had some recent experiences in California: the August earthquake in Hollister, the October earthquake in El Centro, and, within the past 10 days, the earthquakes in Livermore. These experiences have been carefully studied. The information from them is a part of the resources that are available for much needed further exploration in the earthquake prediction area. Our collaboration here is primarily with NSF and USGS. We believe that the programs in those agencies are moving in the right direction. We will be reviewing their programs with them to see if there are additional points of emphasis that should be pursued.

As a result of the Committee on Seismic Safety in Construction, there are information, design, and construction standards, which hopefully will provide a greater degree of protection in the event of an earthquake emergency.

We've been engaged in the sponsorship of law studies and preparedness planning in a number of the areas where there is high vulnerability to earthquakes. There have been studies made in San Francisco, in the Puget Sound area, in Salt Lake City, and in Los Angeles. There are projected studies in Anchorage, Alaska, and in other points of possible vulnerability. We're working very closely with the States, particularly the States of California and Utah, which have organized their own efforts. Only in the last 2 days we have had a meeting on earthquake warning in Los Angeles with representatives from a number of the States and localities in the States.

As far as fire research is concerned, this is one of the four major programs of the U.S. Fire Administration. The Center for Fire Research at the National Bureau of Standards has been the recipient of funds appropriated for the U.S. Fire Administration, and they are pursuing a program that is in step with the interests of the U.S. Fire Administration. We've been working with the ISETAP organization and with the AAS group in dealing particularly with the issues of protection of the firefighters themselves. This is a major concern because the data that we have shows that a significant portion of the loss of life from fires is inflicted on those who fight the fires for us. We believe that more research can be conducted with respect to protective clothing and other technological techniques that would reduce that degree of hazard.

The emphasis is also on protection against residential fires, where a large portion of the losses of life and property take place. The scientific efforts are addressed to what can be done to provide smoke detectors and sprinklers that can assist in giving early warning and in combating the initial fire-up.

We are also interested in pursuing research on fire causes that can be made a part of the knowledge of those who are responsible for fire suppression.

We have just launched, Mr. Chairman, in conjunction with other Federal agencies, an attack on the problem of arson in our country. With funds made available by LEAA, a number of States and localities are launching a coordinated attack, through a task force, on the problem of arson. It would be our hope that some of the benefits of research would be made available to implement that particular attack.

On your question with respect to trends, it would perhaps be presumptuous for an agency still in its first year to indicate trends that come from its own experience. But from the early considerations that Mr. Greene and I have made with our staff concerning the research activities of this agency, we find trends that we believe will give us guidance in dealing with research in this area.

One has already been mentioned twice, and that is the necessity for interdisciplinary research, a recognition of the blurred boundaries between various areas of science, and the blurred boundary between basic and applied research. Our concern in this agency is for application. We are interested in providing a bridge from the laboratory into application at the point where the citizen is threatened by emergencies of all kinds.

We feel that there is a rising importance and capacity in the biological and social sciences that needs to be added to the capability in the physical sciences in order to provide that kind of application.

We're aware of the problems of complexity and the problems that large-scale institutions pose insofar as protection from emergency is concerned. Therefore, there is a need to bring together the various scientific and technological forces to deal with that.

We believe there are two areas where there is need for particular attention. One is the whole area of the total impact of technology as a force that produces emergencies or hazards that require attention in order to protect the citizenry, the side effects, the aftereffects, that have come from technology, particularly those relating to chemistry, we see at Love Canal, we see in the Valley of the Drums, we see in the accidents that occur, that do affect the safety of the citizen.

The second area is the area of telecommunications and information. At the heart of every plan to deal with emergencies the relationship of communications to the necessary action is always important, and so this is an area which we will be giving particular attention.

The availability of electronic capability to assist us in early warning and in sustaining the necessary interconnection of information is critical.

In conclusion, Mr. Chairman, let me say that the basic mission of the Federal Emergency Management Agency is assimilation and application of understanding of new developments as a necessary condition for the management of national safety, security, and survival. The emphasis in that purpose is the application of knowledge to meet the requirements that will lessen the incidence of emergency and reduce the destructiveness of conditions that constitute emergencies. It is the intention of this agency to work closely with other agencies of the Federal Government, to work closely with State and local government, and with interested private organizations, as an orchestrator, as a catalytic agent, to see what can be done to lessen the potential loss of life and property in our society from emergencies of all kinds.

Thank you very much.

[The prepared statement of Mr. Macy follows:]

STATEMENT OF MR. JOHN W. MACY, JR.
DIRECTOR, FEDERAL EMERGENCY MANAGEMENT AGENCY

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

JANUARY 30, 1980

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MR. CHAIRMAN, IT IS WITH GREAT PLEASURE THAT I APPEAR BEFORE THE COMMITTEE ON SCIENCE AND TECHNOLOGY TO DISCUSS THE CURRENT AND FUTURE RESEARCH AND DEVELOPMENT PROGRAMS OF THE FEDERAL EMERGENCY MANAGEMENT AGENCY. AS THIS IS OUR FIRST APPEARANCE BEFORE THE COMMITTEE, I BELIEVE IT WOULD BE USEFUL TO DESCRIBE BRIEFLY THE MISSION OF THE AGENCY. THIS WILL HELP TO PUT OUR R&D PROGRAMS IN CONTEXT.

MR. CHAIRMAN, THE FEDERAL EMERGENCY MANAGEMENT AGENCY WAS ESTABLISHED AS A RESULT OF PRESIDENT CARTER'S REORGANIZATON PLAN #3 OF 1978, WHICH TOOK EFFECT ON APRIL 1, 1979.

AS A RESULT OF THIS PLAN AND SUBSEQUENT EXECUTIVE ORDERS, FIVE AGENCIES AND SEVERAL DISASTER-RELATED ACTIVITIES HAVE BEEN CONSOLIDATED INTO A SINGLE ORGANIZATION REPORTING DIRECTLY TO THE PRESIDENT.

FEMA IS RESPONSIBLE FOR THE COORDINATION AND MANAGEMENT OF FEDERAL ACTIVITIES INVOLVED WITH PREPAREDNESS, MITIGATION, AND RESPONSE TO NATIONAL EMERGENCIES RANGING FROM NATURAL AND MAN-MADE DISASTERS TO NUCLEAR ATTACK. WHILE FEMA HAS OPERATIONAL MANAGEMENT FOR IMPORTANT PROGRAMS IN THESE AREAS, IN LARGE PART, THE EXECUTION OF THE PREPAREDNESS, MITIGATION AND RESPONSE ACTIVITIES CONTINUES TO REMAIN IN THE FEDERAL AGENCIES CHARGED WITH THESE RESPONSIBILITIES.

THE REORGANIZATION WAS DESIGNED TO ACHIEVE SEVERAL OBJECTIVES:

- TO MAKE A SINGLE AGENCY, AND A SINGLE OFFICIAL, ACCOUNTABLE TO THE PRESIDENT AND THE CONGRESS FOR ALL FEDERAL EMERGENCY-PREPAREDNESS, MITIGATION AND RESPONSE ACTIVITIES;
- TO CREATE A SINGLE POINT OF CONTACT FOR STATE AND LOCAL GOVERNMENTS, WHICH HAD URGED STRONGLY THE CONSOLIDATION OF FEDERAL EMERGENCY PROGRAMS;
- TO ENHANCE THE DUAL USE OF EMERGENCY-PREPAREDNESS AND RESPONSE RESOURCES AT ALL LEVELS OF GOVERNMENT BY TAKING ADVANTAGE OF SIMILARITIES IN PLANNING AND RESPONSE ACTIVITIES FOR PEACETIME AND ATTACK EMERGENCIES; AND,
- TO PROVIDE AN IMPROVED BASIS FOR DETERMINING THE RELATIVE BENEFITS AND COST-EFFECTIVENESS OF SPENDING FOR HAZARD MITIGATION, PREPAREDNESS PLANNING, RELIEF OPERATIONS AND RECOVERY ASSISTANCE.

THERE ARE SIX MAJOR PROGRAMS IN THE AGENCY:

- PLANS AND PREPAREDNESS IS RESPONSIBLE, AS THE NAME IMPLIES, FOR FOSTERING PREPAREDNESS AT THE LOCAL, STATE AND FEDERAL LEVELS TO RESPOND TO NATIONAL SECURITY EMERGENCY AND DISASTERS.
- THE DISASTER RESPONSE AND RECOVERY PROGRAM MANAGES FEDERAL ASSISTANCE ACTIVITIES IN THE EVENT OF A PRESIDENTIALLY DECLARED EMERGENCY OR MAJOR DISASTER.
- TRAINING AND EDUCATION CONDUCTS PROGRAMS OF MANAGEMENT AND TECHNICAL TRAINING FOR FEDERAL, STATE AND LOCAL OFFICIALS AS WELL AS THOSE OF PRIVATE ORGANIZATIONS ENGAGED IN EMERGENCY MANAGEMENT.
- THE UNITED STATES FIRE ADMINISTRATION CONDUCTS A WIDE-RANGING PROGRAM OF FIRE DATA COLLECTION AND ANALYSIS, EQUIPMENT DEVELOPMENT, RESEARCH ON ISSUES RELATING TO RESOURCE ALLOCATION, AND FIREFIGHTER HEALTH AND SAFETY. IT COORDINATES THE EXCELLENT FIRE RESEARCH AND TECHNOLOGY PROGRAM OF THE NATIONAL BUREAU OF STANDARDS CENTER FOR FIRE RESEARCH. IT IS ALSO RESPONSIBLE FOR THE RECENTLY ESTABLISHED U.S. FIRE ACADEMY. I WILL DISCUSS THIS AREA IN MORE DETAIL.
- THE FEDERAL INSURANCE ADMINISTRATION DIRECTS THE NATIONAL FLOOD INSURANCE AND FLOOD MITIGATION PROGRAMS. IT IS RESPONSIBLE ALSO FOR THE FEDERAL CRIME INSURANCE AND RIOT REINSURANCE PROGRAMS.

THE SIXTH MAJOR PROGRAM IS MITIGATION AND RESEARCH; IT IS THE FOCUS FOR OUR RESEARCH AND DEVELOPMENT ACTIVITIES. THIS IS A NEW PROGRAM IN THE AGENCY -- A COMPLETELY NEW THRUST -- IT DID NOT EXIST IN ITS PRESENT COMPREHENSIVE FORM PRIOR TO THE ESTABLISHMENT OF FEMA.

THE MITIGATION AND RESEARCH (M&R) PROGRAM IS DIRECTED AT INCREASING THE CAPABILITY OF THE UNITED STATES TO PREDICT, PREVENT AND RESPOND TO EMERGENCIES AND DISASTERS AND RECOVER FROM THEIR IMPACTS. THE OBJECTIVE OF THIS PROBLEM-FOCUSED PROGRAM IS TO APPLY SCIENTIFIC AND ENGINEERING KNOWLEDGE TO REDUCING AND MITIGATING THE LIFE LOSS, INJURY, DAMAGE AND ECONOMIC AND SOCIAL DISRUPTION FROM SUCH OCCURRENCES. ACTIVITIES ARE OR WILL BE DIRECTED AT A BROAD SPECTRUM OF DISASTERS, EMERGENCIES, AND HAZARDS INCLUDING: (A) NATURAL, GEOPHYSICAL DISASTERS, SUCH AS EARTHQUAKES, FLOODS, HURRICANES, TORNADOES AND OTHER SEVERE STORMS; (B) TECHNOLOGY-INDUCED HAZARDS, SUCH AS URBAN AND INDUSTRIAL FIRES, LARGE-SCALE EXPLOSIONS, AND THE RELEASE OF TOXIC, CHEMICALLY REACTIVE AND RADIOACTIVE MATERIALS IN POPULOUS AREAS; (C) CATASTROPHIC FAILURES IN KEY NETWORK AND DISTRIBUTIVE SYSTEMS, SUCH AS ELECTRIC POWER BLACKOUTS, AND THE DISRUPTION OF OTHER PUBLIC UTILITY AND TRANSPORTATION SYSTEMS; AND (D) INTENTIONALLY PRODUCED EMERGENCIES AND DISASTERS, RANGING FROM PEACETIME ACTS OF TERRORISM, SABOTAGE, VANDALISM, AND BLACKMAIL TO THERMO-NUCLEAR WAR.

THE PROGRAM BUILDS UPON THE ONGOING RESEARCH AND APPLICATIONS PROGRAMS OF OTHER FEDERAL AGENCIES AND IS CONDUCTED IN COORDINATION WITH THEM. WE DO NOT INTEND TO DUPLICATE THEIR PROGRAMS. IN ADDITION, THE PROGRAM COORDINATES THE RESEARCH AND MITIGATION ACTIVITIES OF ALL FEMA OFFICES TO ENSURE THAT THEY ARE NOT DUPLICATIVE AND THAT THEY CONTRIBUTE TO OVERALL FEMA OBJECTIVES.

MITIGATION AND RESEARCH ACTIVITIES ARE DIRECTED AT REFLECTING THE NEEDS OF A BROAD SPECTRUM OF POTENTIAL USERS--STATE AND LOCAL OFFICIALS, VOLUNTARY AGENCIES, PROFESSIONAL SOCIETIES, ACADEMIC AND RESEARCH ORGANIZATIONS, INDUSTRIAL AND COMMERCIAL INTERESTS, THE GENERAL PUBLIC, AND OTHER FEDERAL AGENCIES.

THERE ARE FOUR PROGRAM AREAS IN MITIGATION AND RESEARCH: APPLICATIONS, NATURAL AND TECHNOLOGICAL HAZARDS, NATIONAL SECURITY, AND SYSTEMS ANALYSIS AND INTEGRATION.

THE APPLICATIONS ACTIVITY HAS AN EXTERNAL FOCUS. ITS PRIMARY PURPOSE IS OUTREACH TO THE USER COMMUNITY. IT WILL SERVE AS A COMMUNICATIONS LINK WITH STATE AND LOCAL GOVERNMENTS AND OTHER INSTITUTIONS IN IDENTIFYING THEIR RESEARCH AND MITIGATION REQUIREMENTS AND ENSURING THAT USEFUL, USABLE RESULTS ARE MADE AVAILABLE TO THEM. THIS PROGRAM SERVES AS THE FOCUS FOR DAY-TO-DAY INTERACTIONS WITHIN FEMA, THE FEDERAL AGENCIES, PUBLIC INTEREST AND VOLUNTEER GROUPS. IT ALSO PROVIDES TECHNICAL SUPPORT TO FEMA REGIONS AND HEADQUARTERS OFFICES ON TECHNICAL PROBLEMS OF AN IMMEDIATE NATURE--THOSE REQUIRING 30 TO 90 DAY RESPONSE. PROTOTYPE MITIGATION FIELD TESTS ARE ALSO ITS RESPONSIBILITY. IN ADDITION, THE APPLICATIONS ACTIVITY HAS BEEN ASSIGNED THE RESPONSIBILITY TO DEVELOP A DATA BASE ON NATIONAL MITIGATION AND RESEARCH ACTIVITIES ACCESSIBLE TO THE USER COMMUNITY.

NATUAL AND TECHNOLOGICAL HAZARDS ACTIVITIES ARE CONCERNED WITH THE DEVELOPMENT AND APPLICATION OF KNOWLEDGE REQUIRED TO LESSEN THE IMPACTS OF EARTHBORNE, WATERBORNE, WINDBORNE, AND MAN-MADE HAZARDS. WITHIN THIS PROGRAM AREA, FEMA HAS RESPONSIBILITY FOR THE EARTHQUAKE HAZARDS REDUCTION ACT WHICH IS DIRECTED AT MITIGATING THE EFFECTS OF EARTHQUAKES AND THE DAM SAFETY PROGRAM WHICH IS DIRECTED AT ENSURING A COORDINATED FEDERAL PROGRAM TO PROMOTE DAM SAFETY. RECENTLY, WE LED AND COMPLETED AN INTERAGENCY STUDY ON GROUND SUBSIDENCE, WHICH IS ABOUT TO BE PUBLISHED. THERE IS ALSO A PROGRAM OF FLOOD RESEARCH IN SUPPORT OF THE FEDERAL INSURANCE ADMINISTRATION. WE PLAN TO UNDERTAKE A NUMBER OF INTERAGENCY REVIEWS TO DETERMINE WHAT SPECIAL MITIGATION ACTIVITIES SHOULD BE UNDERTAKEN ON LANDSLIDES, TSUNAMIS, DROUGHT, HURRICANES, TORNADOES AND SO FORTH. IN ADDITION, STUDIES OF WAYS TO MINIMIZE THE IMPACTS OF ACCIDENTS AND EXPLOSIONS AND ATTENDANT FIRES, ARE PLANNED.

NATIONAL SECURITY ACTIVITIES ARE DIRECTED AT INCREASING THE PROTECTION OF THE NATION'S POPULATION FROM NUCLEAR WEAPONS EFFECTS. THEY INCLUDE STUDIES OF POPULATION RELOCATION TO AREAS LESS VULNERABLE TO ATTACK AND THE PROTECTION OF CRITICAL INDUSTRIES FROM DESTRUCTION IN CASE OF ENEMY ATTACK. RESEARCH ON POSSIBLE NUCLEAR PEACETIME INCIDENTS IS ALSO INCLUDED IN THESE PROGRAMS.

SYSTEMS ANALYSIS AND INTEGRATION ACTIVITIES INCLUDE THE CONDUCT OF PROBLEM DEFINITION STUDIES TO DELINEATE PROBLEMS AND DEVELOP RESEARCH REQUIREMENTS- ENGINEERING, SOCIAL, ECONOMIC, LEGAL AND INTERGOVERNMENTAL- WHICH WILL ASSIST IN SOLVING OR IN MITIGATING THE PROBLEM. CURRENTLY, THERE IS A STUDY UNDERWAY TO DETERMINE WHAT FEMA SHOULD BE DOING IN THE TOXIC CHEMICALS AREA. THE SYSTEMS GROUP IS ALSO RESPONSIBLE FOR STUDIES IN SUCH AREAS AS: THE GENERAL PATTERNS OF RESPONSE AND BEHAVIOR UNDER EMERGENCY CONDITIONS; ANALYSES OF THE BENEFITS AND IMPACT OF MITIGATION MEASURES; DECISION PROCESSES INVOLVED IN EMERGENCIES; AND CRITERIA FOR THE EVALUATION OF EMERGENCY RESPONSE.

I WOULD NOW LIKE TO TURN TO THE EARTHQUAKE HAZARDS REDUCTION PROGRAM AND THE FIRE RESEARCH PROGRAM WHICH ARE OF SPECIAL INTEREST TO THE COMMITTEE.

NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM

THE FEDERAL EMERGENCY MANAGEMENT AGENCY IS RESPONSIBLE FOR THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM. IN ACCORDANCE WITH P.L. 95-124, THE PRESIDENT HAS ASSIGNED FEMA THE FOLLOWING RESPONSIBILITIES, AMONG OTHERS:

-- OVERALL COORDINATION OF FEDERAL DEPARTMENTS AND AGENCIES' PROGRAMS IN RESEARCH AND APPLICATION;

-- LEADERSHIP AND SUPPORT TO THE FEDERAL INTERAGENCY COMMITTEE ON SEISMIC SAFETY IN CONSTRUCTION AS IT DEVELOPS SEISMIC DESIGN AND CONSTRUCTION STANDARDS FOR FEDERAL PROJECTS;

-- EXAMINATION OF THE APPROPRIATE ROLE OF INSURANCE IN MITIGATING THE IMPACTS OF EARTHQUAKES;

-- RESPONSE PLANS AND ASSISTANCE TO STATE AND LOCAL GOVERNMENTS IN THE PREPARATION OF THEIR PLANS.

MR. CHAIRMAN, FEMA WAS ASSIGNED LEAD AGENCY RESPONSIBILITY FOR THIS PROGRAM ON JULY 15, 1979. PREVIOUSLY THE RESPONSIBILITY WAS WITH THE OFFICE OF SCIENCE AND TECHNOLOGY POLICY.

THE LAST YEAR HAS SEEN TWO IMPORTANT EARTHQUAKES IN CALIFORNIA--ONE NEAR HOLLISTER, AND THE OTHER IN EL CENTRO. IN THE AUGUST EVENT (HOLLISTER) THE DATA COLLECTED ON SEISMIC WAVE VELOCITIES, TILTING--THAT IS, DEFORMATION OF THE EARTH'S SURFACE--STRAIN CHANGES, WATER WELL LEVELS, CHANGES IN MAGNETIZATION AND OTHER SCIENTIFIC INFORMATION, REPRESENTS A UNIQUE SET OF INFORMATION. ALTHOUGH ANALYSIS OF THIS DATA, TO DATE, HAS NOT INDICATED ANY STRONG PRECURSORY EVIDENCE, IT NONETHELESS REPRESENTS AN IMPORTANT STEP FORWARD TOWARDS THE DAY WHEN EARTHQUAKE PREDICTION PRECURSORS ARE IDENTIFIED.

THE EL CENTRO EARTHQUAKE IN OCTOBER, HAS PROVIDED THE MOST COMPREHENSIVE STRONG MOTION DATA EVER YET COLLECTED. THESE DATA ARE NECESSARY TO FORMULATE ADEQUATE ENGINEERING DESIGN LOAD INFORMATION. FROM AN ENGINEERING POINT OF VIEW, THESE DATA REPRESENT A UNIQUE OPPORTUNITY TO IMPROVE OUR UNDERSTANDING OF THE FORCE APPLIED TO BUILDINGS DURING DAMAGING EARTHQUAKES. THIS EVENT HAS PROVED TO BE A MOST VEXING ONE IN THAT THE DAMAGE WHICH DID OCCUR WAS IN SOME WAYS UNEXPECTED AND DAMAGE WHICH WAS EXPECTED DID NOT OCCUR.

OBSERVATION OF THESE TWO EARTHQUAKES REINFORCES OUR UNDERSTANDING OF THE DIFFICULTY OF THE SCIENTIFIC AND TECHNOLOGICAL ISSUES FACING US IN DEVELOPING A CAPABILITY TO PREDICT

EARTHQUAKES AND TO PROVIDE DAMAGE RESISTANT STRUCTURES. THE, AS YET UNSOLVED, BASIC AND APPLIED RESEARCH PROBLEMS IN EARTHQUAKE AREAS ARE ENORMOUS AND WARRANT A CONTINUED SUBSTANTIAL FEDERAL RESEARCH INVESTMENT. THE NATIONAL SCIENCE FOUNDATION AND THE U.S. GEOLOGICAL SURVEY, NO DOUBT, WILL DISCUSS BEFORE THIS COMMITTEE THE EXCELLENT SCIENTIFIC PROGRESS THEY ARE MAKING.

WE ARE PARTICULARLY PLEASED WITH THE PROGRESS BEING MADE BY THE INTERAGENCY COMMITTEE ON SEISMIC SAFETY IN CONSTRUCTION (ICSSC). IT IS CHAIRED BY FEMA, AND OVER 130 INDIVIDUALS IN 17 FEDERAL AGENCIES PARTICIPATE. THE COMMITTEE HAS THREE PRINCIPAL OBJECTIVES:

- -- DEVELOP SEISMIC DESIGN AND CONSTRUCTION STANDARDS FOR FEDERAL PROJECTS;
- -- DEVELOP GUIDELINES TO ENSURE SERVICEABILITY FOLLOWING AN EARTHQUAKE OF VITAL FACILITIES CONSTRUCTED OR FINANCED BY THE FEDERAL GOVERNMENT; AND,

-- DEVELOP GUIDELINES THAT PROVIDE FOR INDEPENDENT AND STATE AND LOCAL REVIEW OF SEISMIC CONSIDERATIONS IN THE CONSTRUCTION OF CRITICAL FACILITIES CONSTRUCTED AND FINANCED BY THE FEDERAL GOVERNMENT, WHERE APPROPRIATE.

WE ARE RECEIVING EXCELLENT COOPERATION FROM THE AGENCIES, AND WE EXPECT TO COMPLETE THESE ASSIGNMENTS UNDER THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM.

THE BUILDING SEISMIC SAFETY COUNCIL (BSSC) WAS ESTABLISHED IN APRIL 1979, AS AN INDEPENDENT, VOLUNTARY BODY TO ENHANCE THE PUBLIC'S SAFETY AND TO FOSTER IMPROVED SEISMIC SAFETY PROVISIONS. THE COUNCIL WAS FORMED THROUGH THE EFFORTS OF FEMA AND ORGANIZATIONS REPRESENTING ALL SEGMENTS OF THE BUILDING INDUSTRY. THE COUNCIL'S OBJECTIVE IS TO PROMOTE THE DEVELOPMENT OF SEISMIC PROVISIONS SUITABLE FOR USE THROUGHOUT THE UNITED STATES.

THE FIRST SPECIFIC TASK UNDERTAKEN BY THE COUNCIL IS TO REVIEW THE TENTATIVE PROVISIONS FOR THE DEVELOPMENT OF SEISMIC REGULATIONS FOR BUILDINGS.

A THRUST OF THE FEMA PROGRAM IS EARTHQUAKE LOSS STUDIES AND PREPAREDNESS PLANNING. WE HAVE COMPLETED LOSS STUDIES WHICH IDENTIFY THE POTENTIAL DISTRIBUTION OF DAMAGE FOR THE SAN FRANCISCO BAY AREA, LOS ANGELES, PUGET SOUND AND SALT LAKE CITY. A PREPAREDNESS PLAN TO MOBILIZE AND COORDINATE FEDERAL RESPONSE FOR THE SAN FRANCISCO AREA IS NOW COMPLETE. DURING THIS PAST YEAR, WE HAVE UNDERTAKEN LOSS STUDIES FOR THE ANCHORAGE AND HONOLULU AREAS. OUR CURRENT PLANS INCLUDE SIMILAR LOSS STUDIES IN NEW ENGLAND, SOUTH CAROLINA, NEW YORK AND THE CENTRAL UNITED STATES. FURTHER, WE PLAN TO COMPLETE FEDERAL PREPAREDNESS PLANS FOR EACH OF THESE AREAS.

THE STATES OF CALIFORNIA AND UTAH ARE NOTABLE IN THEIR ACTIONS TO DEVELOP EARTHQUAKE HAZARDS REDUCTION PROGRAMS. THE SEISMIC SAFETY COUNCILS OF EACH STATE HAVE PREPARED PLANS TO MITIGATE EARTHQUAKE HAZARDS. THE CALIFORNIA PLAN IS PARTICULARLY NOTABLE IN THE WAY IN WHICH IT COMPLEMENTS AND EXTENDS THE NATIONAL PROGRAM. THE CITY OF LOS ANGELES, THROUGH ITS TASK FORCE ON EARTHQUAKE PREDICTION, HAS DEVELOPED A NUMBER OF RECOMMENDATIONS TO THE COMMUNITY ON HOW TO RESPOND TO EARTHQUAKE PREDICTIONS. WE BELIEVE THAT THESE AND OTHER ACTIONS TAKEN BY THE STATES AND LOCAL COMMUNITIES DEMONSTRATE THAT THEY ARE ACCEPTING THEIR PORTION OF THE RESPONSIBILITY FOR MITIGATING THE CONSEQUENCES

OF EARTHQUAKES. THUS, CONTINUED FEDERAL PROGRAMMATIC INVESTMENT IN SUPPORT OF THE STATES AND PUBLIC IS WARRANTED FOR MITIGATING THE CONSEQUENCES OF EARTHQUAKES.

FIRE RESEARCH

WITH REGARD TO RESEARCH ACTIVITY IN THE FIRE AREA WHICH IS OF PARTICULAR INTEREST TO THE COMMITTEE, THE FIRE R&D PROGRAM OF FEMA'S UNITED STATES FIRE ADMINISTRATION IDENTIFIES, REFINES AND TRANSFERS TECHNOLOGIES THAT CAN IMPROVE FIRE SAFETY FOR CIVILIANS AND FIREFIGHTERS. THE RESEARCH AND DEVELOPMENT UNDERTAKEN IS THAT WHICH HAS HIGH COMMONALITY FOR FIRE DEPARTMENTS AND COMMUNITIES ACROSS THE NATION AND WOULD REQUIRE TOO LARGE AN INVESTMENT FOR INDIVIDUAL DEPARTMENTS OR PRIVATE SECTOR ORGANIZATIONS INVOLVED IN THE FIRE PROTECTION FIELD TO UNDERTAKE ON THEIR OWN.

FIREFIGHTING HAS DEATH AND INJURY RATES AMONG THE HIGHEST OF ANY OCCUPATION. WE ESTIMATE, BASED ON THE MOST RECENT CENSUS OF FIREFIGHTER DEATHS, THAT THERE ARE 175 DEATHS PER YEAR IN THE LINE OF DUTY. OVER HALF ARE CAUSED BY HEART ATTACKS. IN ADDITION, THERE ARE OVER 50,000 INJURIES PER YEAR SUSTAINED AT THE FIRE SCENE. ALSO, WHILE A MORE DEFINITIVE STUDY IS NEEDED, IT HAS BEEN ESTIMATED THAT IT COSTS A COMMUNITY UP TO $250,000 FOR EACH DISABLED FIREFIGHTER.

AT THE REQUEST OF THE INTERGOVERNMENTAL SCIENCE, ENGINEERING AND TECHNOLOGY ADVISORY PANEL (ISETAP), THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE CONVENED A WORKSHOP OF NATIONAL EXPERTS TO IDENTIFY THE TYPE OF RESEARCH NEEDED IN THE AREA OF FIREFIGHTER SAFETY. THIS GROUP RECOMMENDED THAT RESEARCH BE FOCUSED ON FOUR AREAS: IDENTIFICATION AND ANALYSIS OF THE CAUSE OF FIREFIGHTER DEATH AND INJURY; FIREFIGHTER PROTECTIVE EQUIPMENT AND TOOLS; FIREFIGHTER PHYSICAL FITNESS; AND FIREFIGHTER MANAGEMENT AND OPERATIONAL TECHNIQUES.

IN 1980 THE FIRE ADMINISTRATION WILL INCREASE ITS WORK ON FIREFIGHTER HEALTH AND SAFETY. STUDIES OF THE TOXIC ENVIRONMENT OF WORKING FIRES TO ASSIST IN DEVELOPING PROTOTYPE LIGHTWEIGHT FIREFIGHTER PROTECTIVE CLOTHING WILL BE CONDUCTED. ALSO, STUDIES OF ACUTE AND CHRONIC DISEASES IN THE FIRE SERVICE WILL BE MADE.

RESIDENTIAL FIRES ARE MAJOR KILLERS. TWO-THIRDS OF ALL FIRE DEATHS DUE TO FIRE OCCUR IN PEOPLE'S HOMES. RECENT FINDINGS ON SMOKE DETECTOR EFFECTIVENESS AND A BREAKTHROUGH IN SPRINKLER SYSTEMS TECHNOLOGY SUGGEST THAT ADDING AUTOMATIC DETECTION AND SUPPRESSION SYSTEMS TO HOMES IS A PRACTICAL AND EFFECTIVE WAY TO REDUCE RESIDENTIAL FIRE CASUALTIES AND LOSSES.

IN 1979, WE PRESENTED THE FIRST NATIONAL STATISTICS ON THE EFFECTIVENESS OF SMOKE DETECTORS. THEY FOUND THAT WHEN A FIRE IN YOUR HOME OCCURS, YOU ARE HALF AS LIKELY TO DIE IF YOU HAVE A SMOKE DETECTOR THAN IF YOU DON'T.

A CRITICAL FACTOR IN MARKET ACCEPTANCE IS THE RELIABILITY OF DETECTORS. THE FIRE ADMINISTRATION WILL EVALUATE IMPROVED SMOKE DETECTORS BY TESTING THEIR RELIABILITY IN ACTUAL FIRES AND WILL PILOT TEST A PORTABLE DEVICE FOR CHECKING THE SENSITIVITY OF INSTALLED DETECTORS.

CONCENTRATING OUR RESOURCES ON ~~RESIDENT~~IAL Public Bldg SAFETY HAS RESULTED IN A RELATIVELY LIMITED EFFORT IN ~~PUBLIC~~ Residential BUILDING SAFETY. CONSEQUENTLY, WE ARE NOT REVIEWING AND EVALUATING INDIVIDUAL FIRE CODES AND HAVE ONLY RECENTLY LAID SOME PRELIMINARY CONCEPTUAL GROUNDWORK FOR FIRE SAFETY EFFECTIVENESS STATEMENTS AS AUTHORIZED UNDER SECTIONS 12 AND 13 RESPECTIVELY OF THE FEDERAL FIRE PREVENTION AND CONTROL ACT OF 1974. SINCE FIRE SAFETY AND CODE ENFORCEMENT HAS PROVEN TO BE A CONTINUOUS PROBLEM IN THE UNITED STATES, WE HOPE TO BE DEVELOPING CODE GUIDES AND MANAGEMENT HANDBOOKS TO ASSIST STATE AND LOCAL OFFICIALS IN IMPROVING INSPECTION AND PROGRAM MANAGEMENT AND ENFORCEMENT OF CODES.

THE CENTRAL PROBLEM IN FIRE PROTECTION IS KNOWING WHAT CAUSES OR HAPPENS IN A FIRE. THERE ARE MANY VARIABLES, THE AMOUNT OF VENTILATION, THE KIND OF IGNITION SOURCE AND DETAILED GEOMETRY OF THE AREA. SINCE IT IS IMPOSSIBLE TO CHECK ALL BUT A TINY FRACTION OF THE RESULTING REAL FIRE POSSIBILITIES, THOSE CONCERNED FOR FIRE SAFETY--WHETHER CODE OFFICIALS, FIRE MARSHALLS OR BUILDERS--MUST RELY ON NON-FACTUAL DATA.

RESEARCH AT THE CENTER FOR FIRE RESEARCH IS AIMED AT REMOVING THE GUESSWORK FROM FIRE SAFETY. BY THE END OF THE 1980'S, A SERIES OF WIDELY APPLICABLE TEST METHODS WILL HAVE BEEN DEVELOPED FOR IGNITABILITY, FLAME SPREAD, SMOKE AND TOXIC GAS PRODUCTION AND HEAT RELEASE. THE RESULTS OF THE COMPUTER CALCULATION WILL SUBSTITUTE FOR ACTUAL BURN TESTS. THUS FOR THE FIRST TIME, ENGINEERS AND CODE OFFICIALS WILL HAVE A MEANS OF ACCURATELY ASSESSING FIRE SAFETY. CONTINUING ADVANCES IN COMPUTER TECHNOLOGY, AS WELL AS IN FIRE SCIENCE, WILL MAKE THESE NEW TOOLS READILY AVAILABLE.

THE SAME COMPUTERIZATION, COUPLED WITH EXPECTED ADVANCES IN AEROSOL SCIENCE AND SMOKE PARTICULATE RESEARCH, MAY GIVE RISE TO A NEW GENERATION OF "SMART" SMOKE DETECTORS. AS KNOWLEDGE

OF FIRE PROCESSES BUILD UP, THE CENTER WILL EXPAND ITS WORK IN BUILDING FIRE SAFETY SYSTEMS WHICH PERMIT DESIGNERS AND CODE OFFICIALS TO FIND THE LOWEST COST WAYS OF ACHIEVING ANY DESIRED LEVEL OF FIRE SAFETY. THE FORERUNNER OF SUCH A SYSTEM WAS RECENTLY COMPLETED AT THE NATIONAL BUREAU OF STANDARDS AND IS NOW BEING PUT IN PLACE--IN PART THROUGH A TRAINING PACKAGE DEVELOPED BY THE PLANNING AND EDUCATION OFFICE OF THE USFA. OTHER STUDIES CONDUCTED BY FEMA HAVE PRODUCED GUIDELINES FOR REDUCING PUBLIC SAFETY INCIDENTS DURING STRESSFUL EVENTS SUCH AS MASS EVACUATIONS. THESE PROCEDURES ARE BEING ADOPTED BY CITIES SUCH AS DALLAS,TEXAS AND ARE READY FOR ADOPTION NATIONWIDE.

CONCLUSION

I WOULD LIKE NOW TO SPEND A FEW MOMENTS ADDRESSING THE THEMES SET FORTH IN YOUR LETTER.

ON THE GENERAL SUBJECT OF TRENDS WITHIN SCIENCE AND TECHNOLOGY, I WOULD OFFER ONE BASIC OBSERVATION, AND THAT IS, THAT ANY ATTEMPT TO DEFINE MAJOR TRENDS WITHIN SCIENCE AND TECHNOLOGY BECOMES VIRTUALLY COINCIDENT WITH A DESCRIPTION OF THE PRESENT AND FUTURE STATUS OF AMERICAN AND WORLD SOCIETY. SCIENCE AND TECHNOLOGY HAVE BECOME INTIMATE DRIVERS OF VIRTUALLY EVERY OPERATION OF OUR CONTEMPORARY WORLD. TODAY, WE AMERICANS LIVE IN AN ALMOST TOTALLY MAN-MADE WORLD--A WORLD WHICH IS THE PRODUCT OF THE HUMAN ENTERPRISE, AN ENTERPRISE LARGELY DRIVEN BY SCIENCE AND TECHNOLOGY. AGAINST THAT BROAD OBSERVATION LET ME DISCUSS SEVERAL TRENDS WHICH I FEEL IMPACT THE FUTURE HEALTH, SAFETY, PROSPERITY, AND VIABILITY OF THE NATION IN A WORLD COMMUNITY. THESE TRENDS HAVE SPECIFIC IMPLICATIONS FOR THE NATION'S ANTICIPATION AND RESPONSE TO DISASTERS AND EMERGENCIES.

TWO FUNDAMENTAL AND TRADITIONAL DISTINCTIONS ARE RAPIDLY BLURRING. FIRST IS THE DISTINCTION BETWEEN SCIENCE, TECHNOLOGY, AND ENGINEERING, AND SECOND IS THE DISTINCTION BETWEEN BASIC AND APPLIED SCIENCE. THE WORLD HAS BECOME SO COMPLEX THAT MANY OF THE MOST SIGNIFICANT PROBLEMS AND OPPORTUNITIES WE FACE TRANSCEND THESE TRADITIONAL

CATEGORIES. CONSEQUENTLY, WE MUST PLACE EMPHASIS ON PROBLEM-FOCUSED RESEARCH DIRECTED AT SOLVING A PARTICULAR PROBLEM. THIS REQUIRES AN INTERDISCIPLINARY APPROACH, INVOLVING THE SEVERAL DISCIPLINES--THE PHYSICAL SCIENCES, THE SOCIAL SCIENCES AND ENGINEERING.

THERE IS INCREASING EMPHASIS ON THE BIOLOGICAL AND SOCIAL SCIENCES IN THE UNITED STATES. THIS DOES NOT IMPLY A DECLINE IN THE PHYSICAL SCIENCES. IT IMPLIES THAT THE BIOLOGICAL AND THE SOCIAL SCIENCES ARE MATURING; THEY ARE BEGINNING TO UNFOLD IN A HUNDRED FRUITFUL NEW DIRECTIONS.

BIOLOGY IS ON THE BRINK OF CREATING MAJOR NEW TECHNOLOGIES--THE TECHNOLOGIES OF GENETIC MANIPULATION, OF BIOMASS, OF ENHANCED PHOTOSYNTHESIS, OR HARVESTING THE OCEAN AND THE BIOLOGICAL RESOURCES OF THE WORLD. IT IS TIMELY, THEREFORE, THAT WE BEGIN A SYSTEMATIC DETERMINATION OF THE IMPLICATIONS OF BIOLOGICAL TECHNOLOGIES FOR THE SAFETY, HEALTH AND SECURITY OF THE NATION.

THE MOVEMENT TOWARD THE SOCIAL SCIENCES IS ONE TOWARD BETTER UNDERSTANDING OF THE DYNAMICS OF PEOPLE IN RELATION TO EACH OTHER AND IN RELATION TO INSTITUTIONS. WE LIVE IN A WORLD OF SUCH COMPLEXITY THAT THOSE RELATIONSHIPS ARE BECOMING A MAJOR CONCERN.

AS I SEE IT, WE ARE MOVING TO A NEW PHASE IN WHICH WE MUST FACE COMPLEXITY DIRECTLY. WE MUST APPLY THE SOCIAL SCIENCES TO HELP US FULLY UNDERSTAND AND COPE WITH ISSUES RELATING TO ATMOSPHERIC POLLUTION, OCEAN RESOURCES, ENERGY ALTERNATIVES, AND THE IMPACTS OF COMPLEX ELECTRONIC SYSTEMS.

WE HAVE PROBLEMS OF SCALE RESULTING FROM SHEER SIZE IN UTILITIES, POWER PLANTS, AND CHEMICAL COMPLEXES OF UNPRECEDENTED SIZE. WE DO NOT UNDERSTAND WELL THE DYNAMICS OR POTENTIAL FOR FAILURE OR COLLAPSE. WE MUST COME TO GRIPS WITH COMPLEXITY IF WE ARE TO ACHIEVE TWO MAJOR NATIONAL OBJECTIVES: FIRST, THE CAPABILITY TO TRULY GENERATE EARLY WARNING ABOUT THE NEGATIVE, DISASTROUS, UNDESIRABLE , OR CATASTROPHIC CONSEQUENCES OF TECHNOLOGY: SECONDLY, THAT THE UNDERSTANDING OF COMPLEXITY IS THE KEY TO BETTER INSTITUTIONS, BETTER MANAGEMENT; BETTER CONTROL, AND BETTER PUBLIC PARTICIPATION.

WITHIN THE TRADITIONAL SENSE OF TECHNOLOGY AS PHYSICAL THINGS, WE SEE THAT THE NEED IS TO GO BEYOND THE IMMEDIATE TO LOOK AT TECHNOLOGY IN A CONTEXT OF TOTAL SYSTEMS. TECHNOLOGY--FROM ITS INCEPTION TO ITS FULL FLOURISHING, TO ITS DECLINE AND DISMANTLEMENT--IS A PROPER POLICY UNIT OF STUDY. TECHNOLOGY MUST BE LOOKED AT FROM THE POINT OF VIEW OF ITS TOTAL POTENTIAL

EFFECTS ON SOCIETY IN THE LONG AND THE SHORT-RUN. TECHNOLOGY IS UNDERGOING MAJOR CHANGES IN THE UNITED STATES. THE SEEMINGLY IRREVERSIBLE INFLATION IN THE PRICE OF ENERGY WILL LAUNCH A HUNDRED NEW TECHNOLOGICAL ENTERPRISES. THE RESULT WILL BE NEW, BALANCED, AND DIVERSE SOURCES OF ENERGY, AND A GREATER DEGREE OF ENERGY INDEPENDENCE. AT THE SAME TIME, THERE WILL BE THOUSANDS OF INVENTIONS TO CONSERVE AND HUSBAND OUR NEW RESOURCES. WE MUST LEARN TO THINK COMPREHENSIVELY AND IN DEPTH ABOUT THIS REVOLUTION IN ENERGY IF WE ARE TO PURGE IT FROM THE BEGINNING OF THE NEGATIVE, THE UNANTICIPATED, AND THE UNDESIRABLE EFFECTS THAT WOULD OTHERWISE BELEAGUER OUR FUTURE. FOLLOWING ENERGY WILL BE SIMILAR PROBLEMS WITH OUR TOTAL RESOURCE BASE--ENERGY IS MERELY A SUBSET OF THE TOTAL RESOURCE PROBLEM.

THE SECOND MAJOR AREA OF TECHNOLOGICAL DEVELOPMENT, AND PERHAPS THE MOST INTELLECTUALLY EXCITING, IS IN TELECOMMUNICATIONS AND INFORMATION. ALL ASPECTS OF AMERICAN SOCIETY, WHICH INVOLVE THE USE OF INFORMATION WILL BE INFLUENCED IF NOT TRANSFORMED AND REORGANIZED AS A RESULT OF THE INFORMATION TECHNOLOGY REVOLUTION. WE HAVE MADE ONLY A FEW GESTURES AT RESEARCH, EVALUATION, AND EXPERIMENTATION TO UNDERSTAND THIS TIDAL WAVE OF CHANGE SWEEPING OVER OUR FUTURE. LET ME CITE THE CASE OF ELECTRONIC FUNDS TRANSFER. ACCORDING TO PRESENT PLANS, BILLIONS OF DOLLARS WILL DAILY FLASH ACROSS THE UNITED STATES IN THE FORM

OF ELECTRONIC ACCOUNTS. WE HAVE LITTLE KNOWLEDGE AS TO THE POSSIBILITY OF ACCIDENTAL DISRUPTION, PSYCHOTIC INTERVENTION, OR THE PLANNED AND SYSTEMATIC DISRUPTION OF SUCH A SYSTEM BY A HOSTILE FOREIGN POWER. BUT WE ARE MOVING AHEAD FULL STEAM. TAKE THE CASE OF COMMUNICATIONS SATELLITES. WHAT WILL HAPPEN AS SIDE EFFECTS OF COMMUNICATION SATELLITES WHEN 40%, 60%, 80% OR 90% OF THE NATION'S COMMUNICATIONS ARE DEPENDENT ON THEM? WHAT KINDS OF NATURAL, UNNATURAL, OR MAN-INDUCED CATASTROPHES COULD DISRUPT THAT SYSTEM? WHAT BACKUPS DO WE NEED? AT WHAT COST?

FOR MY PART, A BASIC MISSION OF FEMA IS THE ASSIMILATION OF THE UNDERSTANDING OF THESE NEW DEVELOPMENTS AS A NECESSARY CONDITION FOR THE MANAGEMENT OF NATIONAL SAFETY, SECURITY, AND SURVIVAL. CLEARLY, IF THE UNITED STATES IS TO DEVELOP A BETTER UNDERSTANDING OF THE CONDITIONS, BOTH PHYSICAL AND SOCIAL, WHICH LEAD TO EMERGENCY OR DISASTER SITUATIONS, A STRONG SCIENTIFIC AND TECHNOLOGICAL BASE IS ESSENTIAL. SIMILARLY, THE DEVELOPMENT OF EFFECTIVE MITIGATION TECHNIQUES WHICH WILL RESULT IN DECREASES IN THE SOCIAL AND ECONOMIC DISRUPTION AND LOSS OF LIFE AND PROPERTY ARISING FROM EMERGENCY CONDITIONS IS HEAVILY DEPENDENT

UPON THE APPLICATION IN AN EFFECTIVE WAY, OF BOTH PHYSICAL AND SOCIAL SCIENCE OUTPUTS. ON ITS PART, FEMA WILL CONTINUE TO WORK CLOSELY WITH THE OTHER FEDERAL AGENCIES WHOSE MISSIONS RELATE TO EMERGENCY MANAGEMENT ISSUES TO ENSURE MAXIMUM COMPLEMENTARITY BETWEEN THEIR RESEARCH AND OURS.

MR. CHAIRMAN, I THANK YOU FOR THE OPPORTUNITY TO PROVIDE COMMENTARY TO YOUR COMMITTEE ON THIS IMPORTANT SUBJECT.

The CHAIRMAN. Thank you very much, Mr. Macy, for your testimony and synopsis of the activities of FEMA. It looks as though you're getting well underway.

In the interest of time—so all the members will have some time—we are going to have to put a 5-minute limit on the members for their questions and answers.

I would like to start with Dr. Atkinson.

You mentioned work in metals and materials and the impact of this on the national well-being. We have already passed a materials policy bill, which I am sure you are familiar with. It passed out of this committee and the House last fall.

What work in any direction is NSF supporting in the development of synthetic materials? I'm thinking of things such as cobalt and other metals that are in short supply or in a very critical state at this time. Has that been given a special emphasis?

Dr. ATKINSON. Mr. Chairman, we have contributed to the President's domestic policy review of this area; the first phase is complete. We also have done a crosscut on the Foundation's activities with synthetic materials in mind, and it is clear that many of our programs—not just those in materials science, but others in the Foundation—are contributing to that activity.

The CHAIRMAN. I know Mr. Harkin is here, and he may have some further questions on it, but the subject that's been very dear to him is automotive R. & D. You indicated that you have about $8 to $10 million for automotive research.

Is this in new types of engines or more efficient engines, or more efficiency of the present type of automotive designs that we have?

Dr. ATKINSON. Mr. Chairman, I was talking about the cooperative automobile research program, a 10-year joint effort by the auto industry and the Government. The Government is to contribute about $800 million; the auto industry about $500 million. The program is to be targeted at basic research as it relates to the automobile industry. Exactly how the program will be funded in this first year has not been decided; I understand that approximately $20 million will be made available for Federal efforts, and that NSF will receive between $8 million and $10 million of the Federal share.

At our industry-university research centers, industrial scientists working in coordination with university scientists will develop joint research programs. The research will be motivated by the scientific opportunities as perceived by the university scientists and the needs of the industry as perceived by the industrial scientists involved in the cooperative research centers.

The CHAIRMAN. Dr. Ambler, are you doing any work at NBS on standards for solar equipment so that the public can be better informed about the quality and the output of solar collectors and other devices connected with that?

Dr. AMBLER. Yes. We have an extensive program supported by a number of other Government agencies in developing test methods for solar collectors, their effectiveness, and their durability. We have a test site where we presently have a number of solar collectors under test at the present time.

The CHAIRMAN. Mr. Macy, you mentioned that you were working with several people in regard to information about natural hazards, such as earthquakes. What about severe weather? Are you coordinating with NOAA and with the National Weather Service on severe weather alerts, on how to notify people better? For instance, in Wichita, a severe tornado hit last year, it was indicated that notice of that was some 2 hours prior to its impact, yet many people did not receive the information, or chose not to try to leave. My time is up. Can you give us a quick answer?

Mr. MACY. Yes. We have a very close working relationship with NOAA. We have in process a new memorandum of understanding between the two agencies in order to make sure that we function as effectively as possible in the event of all emergencies.

The question of early warning is one that's of major importance to us. Tornadoes are particularly difficult. We believe that we're beginning to get improved warning with respect to hurricanes. This resulted in a reduction in the loss of life in Hurricane Frederick on the gulf coast this past year.

The CHAIRMAN. I might say you did an excellent job in that, and in Hurricane David, I think.

Mr. MACY. Yes.

So, really the hope is that we can be more effective, to the extent that the Weather Service has the information, and our belief is that this is one of the areas of major attention insofar as our own mitigation and research activities: How can we receive earlier warning and couple with that the means whereby there can be evacuation or protection for the populations involved.

The CHAIRMAN. I commend you for that.

Mr. Wydler.

Mr. WYDLER. Thank you, Mr. Chairman.

First I want to say hello to Dr. Hackerman. Norm, I think I last saw you at the Los Angeles Airport. That was some months ago.

Dr. HACKERMAN. Yes, I hope you made it back all right.

Mr. WYDLER. I'm glad to see you here today.

I just want to say I understand your time will soon end with the National Science Board. You've made a great contribution to the Board and to our country. I, personally, and everybody I am aware of who knows you and knows what you have done for the Board, is thankful to you for the efforts you've made for our country.

Dr. HACKERMAN. Thank you.

Mr. WYDLER. I'm delighted to see you here because you're not only a good member of the Board, but you're a good person, and a good friend.

Dr. HACKERMAN. Thank you.

Mr. WYDLER. Dr. Atkinson, I'm interested in this program you have to drill in—what do you call it—the median?

Dr. HACKERMAN. The ocean margins.

Mr. WYDLER. The ocean margins. I support that program. It's a program that might produce some more oil supplies, in addition to whatever else you might discover, for our country.

My only problem is: Do you think if we happen to discover some oil in that part of the ocean, we would be allowed to drill it? The problem we have in our country is not so much having resources or even knowing how to utilize them, but finding a willingness on the part of the American public to accept the problems that go along with exploiting our resources. That's the biggest problem we have, frankly, as I see it, in meeting our energy needs.

Will the drilling of ocean margin areas produce additional environmental objections? Will we again learn that we can't do it for one reason or another, that the gas or oil is there, but you just can't utilize it? Do you foresee any particular problems of that kind arising?

Dr. Atkinson. Mr. Wydler, I think you can answer that question better than I can.

[Laughter.]

Mr. Wydler. I wish I could.

I want the committee to think about that, because that is the fate of other programs. It's extolled as being able to break through barriers and give us a new source of energy for our Nation. The unfortunate part is when we arrive at the point where we can actually exploit it and use it then we find out we have a lot of objections to using it because of one problem or another, and nobody is willing to make any sacrifices so that we can exploit the new form of energy.

I just bring that up because I see it arising in one thing after another in our country, and we keep chasing our tails, hoping that the next energy source will be one that can be used with absolutely no risk or penalty, and, of course, that will never happen; it will never come. Everyone will require us to pay a penalty to use it.

I'm just trying to get that message over to the public if I can.

Dr. Atkinson. Mr. Wydler, it is a good message, but I would say that the technology is improving rapidly. That we can conceive of drilling into water depths of 2½ miles and then of drilling into the Earth another 4 miles from a small ship on the water's surface indicates the advances made in the technology.

I think there are problems, but I think the technological advances do deal with many of the environmental issues before us.

Mr. Wydler. Dr. Ambler, I just want to ask you, are you satisfied with your budget?

Dr. Ambler. Yes, sir.

Mr. Wydler. You are?

Dr. Ambler. Yes.

Mr. Wydler. If you could have one thing you didn't get, what would it be?

Dr. Ambler. I think that we would want to strengthen our program in automation.

Mr. Wydler. In automation?

Dr. Ambler. Yes, sir.

Mr. Wydler. Thank you.

Mr. Macy, you are in charge of a new Government agency and its main purpose is, as I understand it, to coordinate all of the emergency efforts so that we have a better Federal emergency response. Essentially, I think that's a fair statement of what you're trying to do.

Mr. Macy. That is correct.

Mr. Wydler. And you're the right man to do it.

Mr. Macy. Thank you.

Mr. Wydler. I'm sorry my time is up. I had a good question. I'll try to get somebody else to yield to me. I have a question for you.

The Chairman. Mr. Brown?

Mr. Brown. I would be glad to yield to Mr. Wydler if he would like to continue.

Mr. Wydler. If you would give me 1 minute, Mr. Brown, I would appreciate it.

Mr. Brown. Yes.

Mr. Wydler. The question I have is this: You have responsibility in the nuclear field. I am presently concerned about what's happening in our country in preparation for nuclear disasters. We are trying to devise very elaborate and very complicated evacuation plans for specific areas where we happen to have nuclear power plants. To me that has some importance. But I'm much more concerned about the possibility of evacuation plans that might be necessary in the case of an atomic attack. The probability of that happening is much greater than the probability of some of these accidents that they're talking about at the nuclear plants, and an attack would be much more devastating to the populations, of course, and require much more in the way of planning and evacuations.

I want to know what are you doing about planning in the event of nuclear attack and the possibility of major population areas being hit with these bombs. What is being done in that area?

Mr. Macy. The two areas that you speak of are closely interrelated. For a number of years there have been efforts made by the Civil Defense organization to achieve a crisis relocation capability for communities that would have the highest vulnerability. The program has not moved as rapidly as I believe many of us would wish, but we are in the process of developing such plans with those communities. There are resources that are made available to the States and the communities with whom we're working. There are planners provided by our agency to the States—in other words, we fund such planners—to work on that kind of crisis relocation.

In connection with the new emphasis on emergency planning for nuclear plants, there is a close interplay between those two purposes. In fact, the same planners will be utilized, and augmented, in order to make certain that there are adequate plans for all 72 of the existing plants and for the additional 90 that will be coming on-line in the years ahead.

So we believe that the two efforts can be mutually supportive. Certainly, we share your conviction that we must deal with the broader and more devastating prospects, as well as deal with the plants themselves.

Mr. Wydler. Thank you very much.

Thank you, Mr. Brown.

Mr. Brown. Mr. Chairman, I'm going to pose just one question, which I doubt the witnesses will have time to answer, but I'll have additional opportunity to take it up with them.

All of the witnesses have pointed to certain converging trends in the field of science and technology. Dr. Atkinson has laid them out very well in his statement. Dr. Hackerman has pointed out the problem of scientific literacy, which stems in part from aspects of this same problem. I guess you could say that the fragmentation or specialization of knowledge makes it difficult to be perceived in its total import and harder for people to assimilate. I'm interested in the trends toward trying to remedy that.

There are problems with the organization and coordination of knowledge found in several of the programs illustrated here. The earthquake program, and others all have certain basic needs in organizing knowledge.

I have a recent study here by the Library of Congress dealing with the subject of biogeochemistry. I didn't even know such a subject existed. But it's an illustration of the convergence of scientific fields. In this brief study, the Library says we're spending about a hundred million dollars on this, and amongst the issues raised is whether or not current information systems for the storage, retrieval, and analysis of data from biogeochemical research are adequate. For example, are data to support epidemiological studies adequately available or adequately organized?

The question I am raising here is are we at the point where we need to subject to analysis our methods of coordinating the organization of knowledge itself, and whether this requires a greater emphasis. You could recruit a data base designer, for example, by advertising for one in the paper. You can recruit an information systems designer. But does the Federal Government have an adequate capability to plan and program the totality of the scientific and technical information that is a requisite for making policy decisions, or even coordinating decisions, in complex, new, converging scientific and technological fields? That's the question I raise, and what we should do about it. If you have time I would appreciate any comments that you might make.

For example, at least two of you are engaged in computer system design, the technology for maintaining data bases more adequately. I don't even know if you talk to each other about it, and do you talk about the broader problems?

Dr. AMBLER. I don't know that this is one of the areas that we discuss very intensely with the Science Foundation or other agencies in the broad sense that you've posed the problem. Most certainly, we are concerned with the organization of information and the dissemination of information.

Frankly, I find that from our own experience one of the best ways to disseminate information is through personal contact, and that is why we constantly stress in our programs this interaction of bringing people in and our people going out.

I'm sympathetic to the need for arranging that information for policymakers. But the thing that always scares me a little bit is a solution that presents the computer information systems as being the central solution to all data problems. Lord knows, we have enough problems with the computer systems that we already have with small data bases, and as you go to bigger data bases you run into more problems.

Mr. BROWN. Let me give you a simple example.

I am told that the Army or the Pentagon has already spent, or committed, $150 million in trying just to design a data system to handle their problems of hospital management, a very small part of the total information needs of our society. If they have really misspent $150 million on that one small problem, can you conceive how big the problem is if you look at the total science and technology data base of the Government and how to organize it more effectively?

Dr. Atkinson. Mr. Brown, it is easy to talk about computer hardware and computer electronics; many advances are being made. But the area where there have been minimal advances in the past is the software area—the concept of data base, programing languages, the theory of information structure, and retrieval processes. One cannot expect industry to invest large amounts of money for new ideas in software, and over the past 10 years there has not been enough support for such ideas.

I commented specifically in my testimony that NSF is requesting a 28-percent increase for computer science research; that increase is separate from hardware aspects of computer systems. It is really concerned with programing languages, organization of data bases, and retrieval and storage. It is something that really needs attention; since we built the electronic capacity, we now recognize that we don't have the theory and the software to use it.

Dr. Ambler. Mr. Chairman, if I may, I would like to pick up on what Dr. Atkinson has just said.

It is really a formidable problem, but it does need to be addressed, and addressed by experts in data base management. But the output, the annual output, of Ph.D's and computer scientists in this country at the present time is falling slightly and is slightly in excess of 200 a year. I am told that there are a number of individual firms who could recruit all of them. As we see this electronics, computer and telecommunications hardware revolution, I think that we need to pay attention either to making sure we have enough people who can use these new technologies intelligently and effectively or we need to make sure that the systems that are built are so friendly and easy to use by nonspecialists that, again, they can be used effectively.

Mr. Macy. Mr. Brown, I believe you have put your finger on a very basic point that faces this agency. Because the agency is concerned with the solution of specific emergency problems that relate to survival it's essential that it have available to it, at the ready, on short notice, technological information which will assist in the guidance of actions in dealing with any of those emergencies.

The problem today is that there are probably many sources of information that are not being tapped, and one of our purposes will be to try to design, in terms of specific hazards, information retrieval systems that will assist. We're facing this in a very specific way at the present time in connection with emergencies related to toxic chemicals. There are 200 separate chemical information systems that exist at the present time. There are eight separate chemical emergency systems outside the Government.

Now, the point that was just made by Dr. Ambler relates to this also, and it relates to the point about scientific literacy because it's necessary for us not only to be able to retrieve that information, but to have it understandable and applicable in terms of action in order to reduce the hazards that are involved.

Mr. Brown. Mr. Macy, I think perhaps we'll want to take up later with you the role your agency could play in developing prototype systems that would help on this problem.

Mr. Macy. I would welcome the opportunity to discuss that with you.

Mr. Brown. Thank you.

The CHAIRMAN. Mr. Goldwater.

Mr. GOLDWATER. Thank you, Mr. Chairman.

I would like to ask a question of all the gentlemen on the panel.

Would you advocate and would you support, if the President called for it, a boycott of any further scientific exchange with Russia?

Dr. ATKINSON. Mr. Goldwater, the NSF has a special role here; it is the source of funds for the U.S.-U.S.S.R. cooperative research program.

Mr. GOLDWATER. Do you know approximately how much that is?

Dr. ATKINSON. It is $3.2 million in NSF's budget. That money goes to U.S. scientists working in cooperation with Soviet scientists.

Mr. GOLDWATER. What's your feeling about it? I mean your personal feeling, not as a representative of the administration.

Dr. ATKINSON. My personal feeling is that I would like to keep in place the framework for scientific exchange. But I would certainly not like to have any new efforts or any major conferences. To put it another way, I wouldn't want to terminate the exchange at this moment, but I also would not want to engage in any new activities.

Dr. AMBLER. I sought policy guidance from the State Department and Dr. Press' office on this because I was concerned about it. The guidance that we received is that, in line with what Dr. Atkinson said, we don't want to dismantle the administrative structure at the present time, but anything that we do with regard to implementing programs would be governed by two criteria. First, either they would be of tremendous programmatic importance and urgency to us, or secondly, that there would be some overriding humane considerations.

We've examined the programs that we conduct in the light of these criteria, and we find that our programs do not fit. So I suspect that, acting under that guidance, which I support, we will be keeping the contacts for the administration open, but we will not be pursuing any of the programs at the present time.

Mr. GOLDWATER. I'm talking about your personal feeling about it, whether that's something that will be healthy or not, or whether you would support it as a scientist.

Dr. HACKERMAN. I believe the contacts should be kept open. Any time you break contacts it's unhealthy. You can't get people back into position to do what you'd like to do if you don't talk to them.

Mr. BROWN. Would the gentleman yield?

Mr. GOLDWATER. Mr. Brown, I would be glad to yield, but I only have 5 minutes. If the chairman will give me an additional 5 minutes I will be glad to yield.

Mr. BROWN. I ask unanimous consent that I may be permitted to speak out of turn for 30 seconds to call attention to the fact that we're having a hearing on this subject tomorrow, and that yesterday I introduced a resolution calling for at least temporary cessation of scientific exchange, just to further the discussion which you have so ably initiated.

Mr. GOLDWATER. Mr. Macy, I've been involved with activities that are now under your department.

Mr. Chairman, may I?

The CHAIRMAN. Go ahead and finish, Mr. Goldwater.

Mr. MACY. Yes, sir.

Mr. Goldwater. Specifically, I've been concerned that the Federal Government is preempting the insurance business, which is in the business of protecting life and property. We do this differently in fire insurance. It's a requirement to have fire insurance before getting a mortgage loan, and that works very well. A house burns down and the Federal Government doesn't come in with their disaster program. But, if we have anything of a natural cause, or a natural disaster, the Federal Government comes in with all their assistance. They do a good job. I'm not critical of them. But sometimes I've felt that we are bypassing a very available phenomenon, and that is the free market and the private resources out there who are experts at making damage assessments and in correlating a recovering program. They do this in all kinds of different accidents that occur, except when there's a natural disaster, when somehow or other the Federal Government gets into it.

I would like to see a study made, if it has not already been made, of the economics of requiring a national comprehensive disaster insurance program that would be coordinated with the mortgage business, to provide the necessary coverage for any kind of a disaster that may occur.

What are the costs that would be incurred by such a program? Are they prohibitive or not? I've never really seen any analysis of this, any study of this, but I think it's a legitimate question. We will continue to have disasters and, unless we replace it with something else, we're going to have the Federal Government, with billions and billions of dollars being poured in, a lot of it very helpful; a lot of it very wasteful. I've seen some of the programs that have been administered in the past.

I would like your agency to take a good, hard look at this and within a reasonable period of time come back with some kind of an evaluation of this concept. I'm sure it's been looked at, but I've never seen any sort of an analysis on it.

Mr. Macy. I appreciate your making the request. This is an area of interest, concern, and responsibility for the new agency.

Generally the policy approach is that the insurance industry is the proper place in which the risk should be insured by the citizen, and that the Government only enters the picture when the risk is of such a magnitude that the marketplace, through its insuring mechanism, is unable to carry it. Congress, as a consequence, has created a Federal program, as they have in the case of flood insurance.

Today we are pursuing a study of insurance with respect to earthquakes, and just what the coverage is.

The prospect of the kind of comprehensive insurance coverage that you're referring to, obviously, would be desirable and beneficial. We're having meetings with the AIA, the Association of Insurance Agencies, to discuss how there can be further collaboration with them. The desire would be to encourage them to carry as much of the risk as possible and that the government, again, as I indicated in my opening remarks, serve only in those instances where the extent of the disaster transcends the capacity of the marketplace, local government, or State government.

The Chairman. That also is not a subject for this committee because the Banking Committee is the one involved in that.

Mr. MACY. The Banking Committee has been very deeply involved in this. But certainly we'd be very pleased to share with this committee the information we have.

The CHAIRMAN. Thank you.

[The information to be provided is as follows:]

The Federal Insurance Administration has been interested in the topic of natural disaster insurance from its inception in 1968. As you know, FIA administers the National Flood Insurance Program which represents the largest Federal program of Federal disaster insurance. FIA has undertaken studies of other natural hazards, particularly the major remaining hazard with little insurance—earthquake. I enclose the 1971 earthquake report of the FIA.

This 1971 report is very interesting in that it reviewed the status of all natural hazards and concluded that, at that time, earthquake was the only major peril not yet adequately covered by insurance. The study also concluded that earthquake insurance was readily available under normal demand conditions through the private sector at reasonable rates at that time, although very few have taken advantage of this insurance. FIA has since continued to research the capacity of the private insurance industry to handle the earthquake risk without Federal backup under any significant degree of mandation of purchase of such coverage. FIA believes that the private companies could not handle this risk without some governmental assistance. We want to be sure of this, however.

The Federal Emergency Management Agency has just received proposals in response to RFP–R–0215—"A Study of the Natural Earthquake Reduction Program." We hope to enter into a contract within 90 days to study earthquake insurance. The objectives of this in-depth study are:

To determine the feasibility of providing adequate earthquake financial protection to individuals and businesses through the mechanism of insurance.

To determine the feasibility of using private enterprise earthquake insurance as a means to encourage local and state government enforcement of land use and building codes to mitigate earthquake damage.

To identify and formulate possible alternative policies and programs (if any are required).

The study will determine the scope and development of the current earthquake insurance market to see how much insurance is sold and where, to review the magnitude of earthquake insurance premium income and losses incurred, and to test the hypothesis that low-frequency, high-severity insurance is not easily sold even at cheap rates but that some mandation requiring purchase might be required. (This hypothesis is based on a Wharton's School intensive study of earthquake and flood insurance markets—Kunreuther, 1978.)

The study will also review the capacity of the private sector in providing the coverage to see if any Federal backup or reinsurance is necessary. If Federal backup is necessary, what is the role of insurance in mitigating the hazard? What new insurance problems does the development of earthquake prediction raise?

I hope that this comprehensive study of earthquake insurance will be of assistance to the Committee when it becomes available in early to mid 1981. We are pleased to advise the Committee that the California Insurance Department is working closely with us in preparing this study and in selecting the contractor, and will be working with us throughout the course of the study.

We continue to believe that the other major hazards are covered through the National Flood Insurance Program or through the extended coverage provisions of normal private fire and homeowners insurance policies. Certainly wind is covered through this mechanism, with Beach Plans made up of all companies pooling the results in the high hazard, hurricane areas of the Southeast coasts.

The remaining uncovered natural hazards include landslide, which we intend to study within the next two years, and other earth movement such as subsidence, sinkholes, and normal erosion. It is our belief that the uncovered natural hazards are of the sort that can be handled through private and state action without Federal intervention. But it is our intent to closely monitor the situation by reviewing disaster relief statstics to see what other hazards need further study. The Committee should know that it is my desire to see disaster relief diminished through programs of safer construction and insurance or other mechanisms that place the burden of risk on those who choose to live in known high risk areas. I believe it is feasible to virtually eliminate disaster relief by the year 2000 to areas of known hazard, and to limit the taxpayer burden to those situations of a truly unpredictable nature. Our earthquake insurance study is a step in that direction. I am also asking Gloria Jimenez to look into the uncovered flood risks such as roads to see if her flood insurance program could further expand in these areas to reduce the Nation's dependence on disaster relief. The vast majority of disaster relief from flooding is now expended on public infrastructure repair, thus this study is very important in my goal of saving taxpayer dollars.

I also am ordering a thorough review, through FIA and our Office of International Affairs, of methods used in other countries to insure natural hazards. In this regard, Congressman Goldwater might be interested in the Spanish "Consortio" which is an all-risk, Federal government-backed type of insurance mechanism. We will study that system.

Pending completion of our earthquake study and a review of the current situation for the major uncovered areas of risk, we believe it would be premature to undertake a study of any mandated National Comprehensive Disaster Insurance Program, particularly absent the hazard mitigation techniques which we believe must go along with the provisions of any Federal monies for insurance purposes, to avoid encouraging unwise construction in high risk zones. I also hesitate to undertake a study which would increase the Federal role in this area until we are certain that the states, working with the private insurance sector, cannot handle the risk through pooling arrangements, state reinsurance backup, or other backup mechanisms, etc.

If the Committee is aware of any major uncovered insurance risk from natural disasters other than earthquake, we would appreciate such information so that we could initiate a broad study of that risk. I assure the Committee of the Federal Emergency Management Agency's commitment to lessen the burden of natural disasters on victims while finding ways to also lessen the burden on taxpayers. The National Flood Insurance Program's principles of a long-range lessening of reliance on disaster relief and a movement to full actuarial rates on all new structures meets these goals for the flood risk. I will leave no stone unturned in seeking similar approaches for other perils, looking first to the states for innovative solutions but being ready to propose National solutions if it seems appropriate.

As to Mr. Goldwater's concerns that in large disasters, Federal assistance may bypass equipment resources of the State and local government or the private sector, I would report that our procedures and policies are designed to ensure maximum practical use of all in-place capabilities to respond to the disaster situations. As an example, we place considerable reliance during natural disasters or other emergencies on using locally available equipment or vehicles which can be rented from local contractors. For instance, a contractor moved equipment from nearby work under contract to perform the rescue efforts at the hospital building of the Veterans Administration that was demolished by the February 1971 earthquake. While it may not be practicable to keep a complete inventory of all equipment resources that are locally available regardless of ownership, good emergency preparedness at the local level should identify key sources who can make equipment available and more timely arrangements to contact them.

The CHAIRMAN. Mr. Glickman?

Mr. GLICKMAN. Thank you, Mr. Chairman.

It's a pleasure to see you, Mr. Macy. We've had some contact recently.

Mr. MACY. We have, indeed. I hope we don't have any additional ones through the same cause.

Mr. GLICKMAN. We had a flood in our district, and Mr. Macy very courteously responded. We couldn't quite get the relief we wanted, but at least we got part of it there.

I would like to ask Dr. Ambler a question about the small inventors program. As I understand it, there is a cooperative arrangement between the Department of Energy and the National Bureau of Standards on some aspect of it. I chaired some hearings where I found that the National Bureau of Standards received over 12,000 applications, or actually evaluation requests, from DOE, and only about 121 were recommended back to DOE for assistance. That figure strikes me as low.

I then wrote the Secretary of Energy, and I said, "Here we have a program that's supposed to encourage inventions in the garages, in the backyards, of America. What's wrong? It hasn't been moving?"

Then I had some contact with people in the Department of Energy, not at the highest level, but at middle levels, telling me that the program is not being given its due.

I just wondered if you might care to comment generally on your role in it. Could it be expanded? Are you hindered by lack of funds?

Dr. AMBLER. We are funded by the Department of Energy for that program. It is conducted in the Office of Energy Related Inventions. We have received about the number of proposals that you suggested since the program started. The inventions are submitted directly to us though, not via the Department of Energy, and then we perform an evaluation and forward the promising ones to the Department of Energy.

Your numbers are about right. We apply two criteria. The inventions must provide an improvement of existing energy conservation or generation techniques and they must be technically feasible. An application of these criteria and an evaluation not only by our own people but outside consultants results in the yield that you suggest. I think about 100 is right and that of those 100 that we forward to DOE about half of those, in turn, have been funded.

Mr. GLICKMAN. I recall I was at a hearing where one of Mr. Nelson's constituents, I believe it was, had some sort of an idea on how to improve fuel efficiency in automobiles.

Just one of these inventions could be a lifesaver for America. But I realize at the same time that there are many, many hundreds of these inventions that are not credible, and I just want to make sure that the program, the institutional basis of the program, is such that you're able to quickly, and expeditiously, and fully review the inventions so that the garages of America know that at least somebody in the Government will seriously look at it, if there is a good idea.

Dr. AMBLER. I think that we're doing the best job that we can, and I think we're doing a very creditable job.

There are, as you might expect, quite a few complaints about the time it takes sometimes. Sometimes it does not take very long. Sometimes inventions will violate some fundamental principle and they can be dealt with very quickly.

Mr. GLICKMAN. You mean like perpetual motion?

Dr. AMBLER. Yes. But for others, in order to be fair to the inventor, we have to make sure that his patent rights are protected and that it receives proper review. I think the average time for dealing with the invention is about 20 weeks.

I do not think we are doing badly, sir. Our attention is constantly drawn to the program, I can assure you.

Mr. GLICKMAN. I'll try to continue to do that too.

Mr. Harkin had to leave, and so I'd like to go back to the automotive research that the National Science Foundation is doing.

In the first place, I have a thing here called Budget Histories. I don't know if the committee prepared that or if that was done by you. But it says: "Cooperative automobile research—Government and industry—Government share to be paid out of oil windfall profits tax income."

Of course, it is speculative right now whether there's going to be any income to be paid out of that. But what concerns me—and this has been Mr. Harkin's concern—is where basic research needs to be done and where jurisdictionally it's going to fall into. Are we looking at a situation here where all basic research, whether on automobiles or materials or what, is going to be funneled through NSF?

Dr. ATKINSON. I would hope not; the Foundation has always taken a strong stand that each mission agency should have a substantial program of basic research in its area of responsibility.

NSF has a role in the automobile research program, but I would not want it to be a major role. I would hope the Department of Transportation would have the lead role.

Mr. GLICKMAN. Thank you.

The CHAIRMAN. Mr. Carney?

Mr. CARNEY. Thank you, Mr. Chairman.

I would like to thank you, Mr. Chairman, for having these witnesses here. It indicates how complex our lives are and how complex Government is.

I was thinking to myself, listening to this questioning going back and forth, that if I asked perhaps 50 to 60 percent of the people in my district if they ever heard of any of these three agencies, I dare say that they would all say "No." What I'm trying to say is perhaps 60 percent of my district doesn't even know that your agencies exist. I'm sure that the American public is not aware of the crucial roles that your agencies play; again a reflection on the complexities of our lives. Mr. Macy, I didn't see in any of your testimony your budget figures. Do you know your budget figures for fiscal year 1981?

Mr. MACY. Yes; would you like a rundown?

Mr. CARNEY. Just in round figures.

Mr. MACY. The total figure for 1981 is $1,252 million.

Mr. CARNEY. Thank you.

Mr. MACY. But I should add there are two very large components in there. One is funds for the insurance program and the other is funds for the disaster assistance program. So that tends to inflate the figure in comparison to the previous year. I believe I have already provided for the committee a breakdown comparing the 2 years.

Mr. CARNEY. I've just received it. Thank you.

My next question is again to you, Mr. Macy.

If it is possible to extract, how much of your agency's effort is put into civil defense?

Mr. MACY. In terms of the 1981 budget figures that you have before you, $120 million would be for activities generally described in the past as civil defense.

Now, the reason I make that equivocation is because some of those funds also relate to other emergencies for which States and localities are preparing themselves. But they have generally been under the rubric of civil defense in the past, and that's the figure we use for civil defense.

Mr. CARNEY. Is there anyone in your agency, or is there a section in your agency, that is carefully monitoring the civil defense activities of the Soviets?

Mr. MACY. That intelligence information comes to us through intelligence channels. We do not have a separate entity for that collection. But we do have in our plans and preparedness organization the relationship of that information to our own program.

Mr. Carney. So you can utilize that intelligence, then, to help you prepare our type of civil defense?

Mr. Macy. That is correct.

Mr. Carney. Thank you. We could go on and on. This is one of the most interesting meetings I've ever attended.

I would like to ask a question of Dr. Ambler. You mentioned how the balance of payments in high-technology trade is profitable to us and yet the total balance-of-payment picture isn't. We also know that our friends and allies, as well as everyone that we trade with throughout the world, are increasing their efforts in these areas, and we no longer enjoy the lead that we always had in high-technology.

Could you comment on this, and on what we could do to bolster our position, either by competition with foreign countries or cooperation with foreign countries? Is it better for us to compete in R. & D. secretively, or should we cooperate with foreign countries, in order to be as competitive as we always have been?

Dr. Ambler. I think you can distinguish between different kinds of R. & D. I'll have to speak now for how I would view it from the vantage point of my own organization.

I think in areas of basic research, long-range research, academic research, in areas of what to us are very basic standards, like measurement standards, cooperation is very beneficial. It's stimulating, and it tends to be more productive than going it alone. In other areas—let's leave aside areas that are concerned with national defense because, obviously——

Mr. Carney. You're absolutely right.

Dr. Ambler. But in areas that involve advanced technology, particularly research in generic technologies that have potential for exploitation for economic advantage, I believe we need to be careful, and more careful than we have been in the past.

Mr. Carney. In other words, not to put words in your mouth, but we should be more competitive? I guess that would be tough. Each instance would have to be weighed very carefully.

Dr. Ambler. I believe we have to compete. There's no question about that. But in some areas there's ways in which you can compete and other ways in which you can cooperate. If it's to our advantage, if we're getting at least as much advantage, through cooperation, as we're giving I think that would be all right. But in areas where we might be giving more than we're receiving in the economic sense, I believe we ought to think about it twice, to say the least.

Mr. Carney. Thank you. The bell has rung.

Mr. Brown. Mr. Anthony?

Mr. Anthony. Thank you, Mr. Chairman.

I have several questions in two main areas of inquiry. Due to the length of time that we have, I would like to highlight the questions and, if you would, take those and then respond back in writing so that you will have more time to fully explore your answers.

I am keenly interested in the area of business productivity, business innovation, industrial innovation, and I have a couple of questions for the National Bureau of Standards. You did mention the area of industrial automation, and I would like to know what, in your view, should be the balance between industrial and governmental R. & D. in this area so that we can have greater industrial innovation, or, greater productivity. Hopefully that would have an impact on our rate of inflation; in 1979, for the first time in many years, we had a net loss of productivity per man-hoer of work, according to the latest study.

The second question is: For several years the National Bureau of Standards has conducted an experimental technology incentives program, and I would like to know what results this program has yielded, and if a final or a summary report has been written.

[The information follows:]

The following information was subsequently received for the record:

1. You mentioned the area of industrial automation in your January 30 Posture hearing testimony. What, in your view, should be the balance between industrial and governmental R&D in this area?

   Industrial participants in a significant AAAS symposium dealing with the relation between industrial innovation and the Federal R&D budget (Washington 1976) stressed that they expected the Federal Government to provide the necessary infrastructure. NBS provides industry with this infrastructure: measurement services, reference data, reference materials, and knowledge. The development of products for commercialization should be left to industry. This very general statement is applicable also to the field of automation. The specific topics appropriate for Government research are, among others, standards and procedures for interfacing machine tools, industrial robots and computers; control strategies and architectures; and on-line measurements and quality control methods. Clearly the Government, and in this case NBS, can make a very strong impact on the development of this modern technology in these critical areas.

2. For several years NBS conducted an "Experimental Technology Incentives Program." What results has this program yielded? Has a final, summary report been written?

The Experimental Technology Incentives Program (ETIP) is an on-going, active program, with projects at different stages of development and implementation. Therefore, a single summary report of the program has not been written. There are, however, summary reports of individual projects which have been completed, and of one major program area which is nearing completion.

ETIP's mission is to develop and disseminate information about the impacts of Federal policies/programs on industrial innovation and about the relationships between innovation and productivity, economic growth, employment, the balance of trade, and other national objectives. In pursuit of this mission, ETIP has a charter somewhat unique in the Federal Government to conduct experiments - the conscious design, implementation, and evaluation of Federal policy/programmatic changes or actions on a small scale. ETIP does this in cooperation with other Federal agencies.

During its first five years of operations, ETIP has achieved the following general results:

- Successfully developed cooperative relationships with other Federal agencies in which they have accepted the concept of "experimental" change and the idea that "experimental" policies or programs can be evaluated to determine what can be learned and not be threatened by it. In so doing, ETIP has begun to build evaluation into the internal workings of these agencies.

- Demonstrated that policy "experiments" can be designed and carried out with cooperating agencies; that these experiments can be evaluated; and that valuable information on innovation and other aspects of the experiment can thereby be generated. To date, ETIP has initiated about 28 such experiments; 16 have been completed and evaluated, and 12 are still in progress. Numerous background studies and exploratory activities in support of these experiments have also been completed.

- Made significant progress in the development and application of theory and methodology of experimentation as related to Federal policies/programs and innovation. Systematic procedures for the practical design, implementation, and evaluation of policy/program changes have been developed and tested in the field with cooperating Federal agencies.

Specifically, ETIP has:

- Developed extensive information on the use of several Federal procurement techniques (e.g., Life Cycle Costing, Value Incentive Clauses, performance standards) designed to increase innovation in the supply of routine products to the Federal market, and the carryover into the civilian market. This information on the complex conditions under which such techniques can be used successfully is now being used by GSA and OFPP in further policy and program formulation;

- Developed trustworthy relationships with a number of regulatory agencies (EPA, FDA, FCC, ICC, CAB, etc.) in which the impacts of Federal regulations on innovation are being carefully examined. "Experiments" in several agencies concerning innovation issues are just now underway, but background work by ETIP has already had the following kinds of results:

  - an exhaustive cataloging and examination of all cases where EPA has already attempted to use market mechanisms (pollution offsets, the bubble concept, etc.) to provide incentives for innovation to meet regulatory requirements;

  - studies which resulted in the economic deregulation of rail transport of fresh fruits and vegetables and of air cargo operations;

  - a study of alternative regulatory reforms to facilitate innovation in the pesticides industry without sacrificing regulatory goals which has resulted in an experimental testing of an efficacy waiver by the EPA Office of Pesticides Programs;

  - a study of alternative ways to accomplish post marketing surveillance of new drugs, which would potentially enable FDA to reduce premarketing regulatory time and costs;

  - the experimental development of a package of management and analytic tools with the Federal Energy Regulatory Commission designed to aid state regulatory commissions in speeding up decisions on electric utility rate cases.

- Developed selected but significant policy information on the regulation and supply of venture capital to technology-based small business, including:

  - a detailed examination of the venture capital market;

  - an in-depth evaluation of the Connecticut Product Development Corporation;

  - the design and implementation of a data base within SEC which is just now beginning to enable them to evaluate the impact of rules changes on technology-based small business.

In the past year, ETIP was also called upon by the DOC AS/S&T to assist in the operations of the Domestic Policy Review on Industrial Innovation - a policy-making effort at the highest levels of Federal Government. During that process, several ETIP staff members and sponsored individuals made significant contributions to the advisory subcommittees and interagency task forces which they helped to staff. In addition to general knowledge about innovation, they particularly distinguished themselves in the areas of: the supply and regulation of venture capital; Federal Procurement policies; Federal tax incentives; Federal support of R&D; and Federal health, safety, and environmental regulation.

Mr. ANTHONY. I have another more detailed question. Rather than read it into the record I'm going to submit that one to you in writing myself so that you will have a better opportunity to answer it.

The budget history that was mentioned talks about "Large increases in Industry/University Cooperative Research and for Small Business innovative research."

My inquiry is: Are you leaning toward small business innovative research to the exclusion of large industry innovative research, or is there still a balanced program for a combination of both?

[The information follows:]

Is NBS leaning more toward small business innovation research to the detriment of big business innovation research?

NBS does not favor small business over large business in any of its programs except where directed by law in the procurement of things or services. Our typical outputs—measurement services, test methods, reference data and reference materials—are used by small and large businesses alike. However, small businesses appear to take more advantage of some our programs because they are more innovative or because they are more isolated and, therefore, need more assistance.

The program of the Office of Energy-Related Inventions is an exception. As is required by statute (42 U.S.C. 5913) OERI is clearly directed at the small inventor.

Mr. ANTHONY. As a satellite to the Federal Emergency Management Agency I am interested in your fire program and what the principal thrust of the fire research programs have been and how they reflect the objectives of the 1974 Organic Act, and how research on fires and other small-scale hazards is coordinated with the research on large-scale disasters.

I have a special interest in the overall area of fire, fire control, and fire prevention. It's a special emphasis that I'm placing this year in my district.

Mr. MACY. We'll be happy to respond to that in writing.

[The information to be provided is as follows:]

RESIDENTIAL FIRE SAFETY

The bulk of the research program in the U.S. Fire Administration is done under the National Fire Data Center, which has responsibility for Section 8 (Fire Technology) of the Federal Fire Protection and Control Act of 1974. Because three-fourths of the deaths and injuries due to fire occur in residences, the majority of our research effort is devoted to residential fire safety. Three major areas of research are underway. They are (1) To achieve earlier detection of fires, smoke detectors have been tested in instrumented houses and evaluated in actual fires. This information is fed to the fire service and to the fire protection industry in order that the public get the best guidance on what works and how to use it, and to help manufacturers improve the product. A national survey of households to obtain data on what fraction of homes have detectors, how they are distributed by socioeconomic and geographic groups, and data on their use has just been completed. This survey oversampled in the Southeast, where fire deaths are highest, to give a sharper picture of smoke detector usage in that area. (2) A related area of research is on "ARRAS," Automatic Residential Remote Alarm Systems. These systems connect smoke or fire detectors to a central alarm bureau, so that alarms may be sent even when the resident is incapacitated (e.g. sick or drunk) or not at home. These systems usually involve a monthly charge, and are becoming more attractive as modern communication systems such as CATV became widespread. We are evaluating ARRAS in the first communities that are using them, and contributing to further pilot tests of these systems. (3) A third area of research is low-cost residential sprinkler systems.

Industrial fire losses have been sharply curtailed because of the widespread use of sprinkler systems. Fire, unlike many other social problems has a technological solution for a large part of the problem—but it costs. The challenge is to transfer the technology to the home, while reducing costs to allow widespread use. This past year the research we sponsored on developing better sprinkler heads created a breakthrough—a fast reacting sprinkler head. It is sensitive enough to detect a fire in its earliest stages when less water is required to extinguish it. This allows the whole system to be made smaller and to work off existing residential water supplies. We are currently testing these new systems in an instrumented house in Los Angeles in cooperation with the Los Angeles fire department and with the technical and financial support of the Center for Fire Research at the National Bureau of Standards.

FIREFIGHTER SAFETY AND HEALTH

Firefighters have one of the highest death rates among various professions. About one half of injuries associated with reported fires are to the firefighters themselves. Part of our research, therefore, is devoted to reducing firefighter casualties. The major program to date in this area has been the development of improved firefighter protective clothing. This project, jointly funded and administered with NASA, led to the development of a prototype helmet, suit, and boots which are now undergoing lab testing. This will be followed by field tests in 5–10 communities around the country.

Other research on firefighters safety and health includes the development of physical performance criteria for doing the firefighting job; evaluation of physical fitness programs for firefighters; and analysis of the contaminants in the atmosphere to which firefighters are exposed in typical structural fires.

MANAGEMENT STUDIES

In firefighting operations, we developed a way for fire departments of various sizes and situations to formulate specifications for pumpers tailored to their own situation. Another project resulted in a computer program for working out fire department personnel scheduling. We also are starting a research project to evaluate the effectiveness of different size crews on the fireground.

CODE ADMINISTRATION

The American Bar Association is researching, under our sponsorship, ways to enforce existing building and fire codes. Code enforcement has been a major problem, and the idea here is to find practical legal approaches that have the desired corrective and deterrent effects. Other code projects involve evaluating the effectiveness of various inspection policies, and how to choose an appropriate code for your community.

These are just some highlights; there are many more individual projects at the U.S. Fire Administration, and also a large body of related work at the Center for Fire Research of NBS.

RELATION TO OTHER RESEARCH

The research on fires is for the most part not related to the research on large-scale disasters—they really are quite separate areas. Coordination of research on fires associated with disasters, and civil defense is anticipated to be done through the new Fire Research Task Force chaired by the Mitigation and Research Office of FEMA. Coordination of basic and applied research in the "normal" living and structural environment is the responsibility of the U.S. Fire Administration. Coordination and interface between these areas will occur by existence of the U.S. Fire Administration's participation on the Fire Research Task Force.

Mr. ANTHONY. I do have a couple of other questions. I can't seem to find them right now. But they have to do with industrial productivity and industrial innovation.

Here it is. This would be to the National Science Foundation witness.

What is the Foundation's role in the President's initiatives on industrial innovation, and what role should the Foundation play in seeing that the research it supports is potentially useful, or in fostering the application of the research it supports?

As a final comment, I would like for you gentlemen to place yourselves in the position of being a Congressman back in your district trying to support the National Science Foundation, and having an irritable and irate constituent and voter walk up to you and say, "Why in the hell are you wasting all that Federal money to study the sex habits of a South African frog?," or some other such example. It seems to be the behavioral sciences area that gets the publicity. It's the area that I'm asked about all the time. So when I try to justify your research and development program, I'm down to a recurrent need. I wish you would give me a good solid answer that I can give to my constituents back home that would justify this part of your program. I'd like to have that now for the record.

Dr. Atkinson. Mr. Anthony, I have been answering that question for a long time. I would be happy to answer for the record, and I would be happy to say something now if you like.

Mr. Anthony. Yes, I would like to have that now, and then I wanted those others for the record, so we could talk about them.

Truthfully, every time I go home, I'm put on the carpet to try to defend these. I'm a strong supporter of your program and a strong supporter of the research because I know it has positive benefits. But, as you well know, the publicity usually ridicules these types of programs.

Dr. Atkinson. Yes, the publicity dates back a long time. Your example—one of the first examples—was the sex life of screwworm fly. The Congress has investigated it. As a result of the research, the role of pesticides and the practice of pest control in this country has been completely reoriented. The eradication of the screwworm fly in your district, in Texas, and in Mexico has had a positive effect on the cattle industry of those areas.

It is easy to attack such research, but the payoff of that work now is so impressive that even The National Enquirer must have some reservation about making these attacks.

Mr. Anthony. I can argue those very clearly, but I guess maybe more on the behavieral ones, such as showing an octopus to somebody who walks into a barnyard; I have a difficult time explaining that to my people.

I'm not trying to be critical. I'm only trying to glean some information so that I can be instructive to my constituents back home.

Mr. Brown. Mr. Anthony, would you yield just a minute?

Mr. Anthony. Yes, I will yield.

Mr. Brown. Dr. Atkinson, I'm sure, can respond adequately. But we're going to devote a special portion of our subcommittee hearing to this precise question, and we'll be glad both to invite you to participate and to give you the results of that to assist you in your dealings with your constituents on that question.

Mr. Anthony. Mr. Chairman, knowing that that hearing is going to be held, I'm going to yield at this point, and I will participate in those.

Mr. Carney. Would the gentleman yield?

Mr. Anthony. Yes, I will yield.

Mr. Carney. Would the chairman be at liberty to say at what time and what date those hearings will be held? I would be vitally interested in those too.

Mr. Brown. Yes, I can do that.

Mr. Carney. Thank you.

Mr. Goldwater. Would the gentleman yield for one quick comment?

Mr. Anthony. Yes, I will yield.

Mr. Goldwater. I hope you don't eliminate those programs because it makes good speech material. [Laughter.]

Mr. Anthony. I'd have to admit that I've used them in my speeches. They're good attention getters. I'll have to say that.

I have one question.

On your 10-year ocean floor drilling program in cooperation with industry, do you have industry partners that are already in the process and that have been successful in offshore drilling? I've read your report.

Dr. Atkinson. It is an active cooperative exchange; the academic community, the National Science Foundation, and the petroleum industry are planning the program and the technological aspects.

Mr. Anthony. A private company like Ocean Drilling & Exploration Co., commonly called Odeco, which presently is the world's largest offshore drilling company, are they participating with you in any way?

Dr. Atkinson. At the moment, Santa Fe is the engineering support contractor.

Mr. Anthony. Again, I'm very interested in this particular program since it is a 10-year program and Odeco happens to be a wholly owned subsidiary of a company that lives in my hometown of only 25,000. They took this program when no one else would listen to them, and they have built it into a very tremendous thing. They now have an offshore drilling rig in the Baltimore Canyon that is the world's largest. I would like to get some information from you if you have it available to you.

Dr. Atkinson. I would be happy to give it to you, and if you have representatives from there who come to Washington, I'd be happy to chat with them.

Mr. Anthony. Thank you, Mr. Chairman.

Mr. Brown. Thank you, Mr. Anthony.

The date of that hearing is on February 20. It will be both morning and afternoon, and we certainly would like to have you participate.

Mr. Carney. Thank you, Mr. Chairman.

Mr. Brown. Mr. Watkins?

Mr. Watkins. Thank you, Mr. Chairman. Dr. Atkinson, I'd like to address a couple of things that have come up recently.

On Mr. Brown's subcommittee we've been doing some evaluation of the NSF charter, and know specifically that there are certain responsibilities of technology development that NSF has. Does NSF have the capability or the priority for doing or carrying out some of these initiatives?

Looking back to October 21 White House initiatives on industrial innovation, NSF was designated as one of the lead roles.

In your estimation, do you feel that you will be able to shift NSF to take some clear leadership in this area?

So I ask further: Do you think that NSF will be able to meet this challenge and, if it is, are we willing to make the changes necessary to do it?

Dr. Atkinson. Mr. Watkins, this is not a new thrust of the Foundation; it is well-established in experimental programs that have paid off. These are not new programs; they are expansion of programs that have been remarkably productive.

Let me make it clear that the Foundation is not involved in technology development; the NSF Act explicitly excludes us from the function of development. But we, of course, are actively involved in pushing basic and applied research toward new technology.

I must tell you, Mr. Watkins, that I am proud of the Foundation's work in this area. I think the issues of innovation are tremendously important, and my interest is firmly fixed on those issues. Yet I don't want to turn every agency of the Federal Government into a development agency as we face these issues.

Mr. Watkins. I concur there.

Let me say I'm very happy to see that you have increased the industry-university cooperative research program and also the small business area; also the Engineering Technology Center, which I'm happy to see.

When do you propose that this center will be brought on board? I'm very enthused about that.

Dr. Atkinson. We haven't decided because we are still waiting for the President's decision on the cooperative automobile research program. If there are funds available in that program, we are thinking possibly of three or four—rather than one—additional university/industry research centers. We are not quite ready to decide what direction the center should take.

Mr. Watkins. I'm very enthused about that; I think it's a step in the right direction.

Also, I would like to mention something I think Mr. Brown articulated much better than I can, and he knows I'm concerned about it. That is, we have reams of information, but getting it organized and making sure the public can reach in and get it through computers and otherwise, I think we are lacking there. I'm planning some legislation to try to place some emphasis on that in the form of financing, directing a certain amount of Federal research dollars be applied to just that area because we continue to just put reams and reams and reams on the shelves or in the tapes and not make it available. I think Agriculture has done a terriffic job along that line, but we haven't done it in a lot of the other areas.

Let me ask Dr. Ambler about another initiative. I remember reading or hearing something about the garage inventor, and trying to get the inventions and innovations screened. I believe I heard or read that we would probably use some regional groups or centers that would assist in screening these inventions.

Do you expect to continue doing this in the District of Columbia area? Is there a possibility that regional groups will do the screening?

Dr. Ambler. I'm not aware of the proposal to create formal centers. However, we do use outside evaluators.

Mr. Watkins. I don't know if I heard you were going to create them, or simply make use of some existing centers that are dealing with innovations and things of this nature.

Dr. Ambler. We do use capabilities outside the Bureau, in universities and other places, to a considerable extent. In fact, I think that every invention that's submitted receives an evaluation from someone on the outside. So that there is considerable use of outside expertise in this program.

Mr. WATKINS. Mr. Chairman, I appreciate the time.

Let me say in closing that we know that industry has been highly successful many times in their technology development as well as their applied research because they have aimed for specific needs, and I think we may have to lean a little bit that way when we have budget problems and we have productivity problems and other problems in the country, and that we have to aim our research a little more and use a 30:30 instead of a shotgun approach.

I'll be looking forward to visiting with all of you in the near future.

Thank you, Mr. Chairman.

Mr. BROWN. Thank you, Mr. Watkins. Mr. Goldwater, do you have any more questions?

Mr. GOLDWATER. Yes, sir.

Mr. BROWN. You're recognized.

Mr. GOLDWATER. Mr. Macy, I didn't get a chance, really, to make myself clear on this insurance business on disasters. I understand that you said this is something you're looking at.

I'm interested in seeing an overview of what you're doing and what you are looking at fairly soon. What I am interested in seeing is whether there is a better way of responding to emergencies.

In California the 1970-71 earthquake we had out there killed some people. The disaster response was a real mess, a lot of fraud, a lot of abuse, and since then I think we've learned from our mistakes and our errors. We're doing a better job in responding to disasters.

But I still feel that there is a bigger role for private industry to play in all of this, and what I am interested in is an analysis of the cost-effectiveness or the economies to the average property owner of shouldering the burden of a comprehensive national disaster insurance coverage program, with probably the Federal Government as the reinsurer, or a backup. I would like to see an analysis of that. I don't know whether you're pursuing that or not, but I would like to see initially an overview of what it is you are looking at in this area. Then I would like to see some kind of comprehensive evaluation of whether in fact private industry, with the Federal Government as the backup or as the reissuer, could take this responsibility of providing economic coverage for property loss.

Mr. MACY. Mr. Goldwater, we will provide a response to your point to the committee, and, even if we're not in a position to give all of the analysis at an early date, we will give you a general outline of what it is that we believe we can provide and a schedule for providing additional evaluation and information.

Mr. GOLDWATER. Dr. Atkinson, I notice that your background is in psychology and applied mathematics.

I've talked to a number of industry people who tell me that much error occurs on midnight shifts of the work force. For instance, in jobs that work the backside of the clock, oftentimes that's where the greatest errors are made. I'm wondering if you or the National Science Foundation have looked at or is looking at circadium rhythm and the synchronization of bodily functions in people working on the backside of the clock or in crossing time zones.

Dr. Atkinson. There has been much research on that topic, Mr. Goldwater. I don't know of any that NSF is supporting at the moment. I do know that the U.S. Army's research program is active in this area; I would be glad to get some of their information and send it to you.

Mr. Goldwater. I notice your own work in the area of memory, and I think that this phenomenon impacts upon memory and, obviously, that in turn would impact upon whatever job or effort that a human being was doing. My great concern is aviation safety, where pilots have to respond to emergency situations while sometimes handicapped by this synchronization of the body rhythms which may be tuned to some other time zone that affects sleepiness or alertness and I wonder if it affects memory.

Dr. Atkinson. Let me pull together what information I can for you. I don't have it at my fingertips. I will send it to you separate from these hearings.

Mr. Goldwater. On the antarctic work that the National Science Foundation is doing, you have an increase in your budget.

My concern is in the support efforts of the antarctic work, aircraft, ships, and what have you. Do you feel that you have sufficient support there? Do you have enough aircraft, ships, and helicopters to support that work, or are you cutting yourself short in this budget?

Dr. Atkinson. Mr. Goldwater, I could answer that, but Dr. Hackerman has just been down there. He has had a firsthand tour; I think he might reply.

Dr. Hackerman. Let me say that I think people can always use more. I believe that the Antarctic support facilities are adequate. But what is most impressive about it, Mr. Goldwater, are the people who man them. The pilots and the crews of the planes and the helicopters, and the crews of the icebreakers are dedicated people, who have the ability to do what is necessary.

I think that the air fleet is wearing out. There are some old aircraft. Two new planes, LC–130's, were procured by NSF in fiscal year 1976, and three new LC–130's in fiscal year 1973. Some major repairs on the two oldest LC–130's will be required in a year or two.

Mr. Goldwater. Is there a need now?

Dr. Hackerman. I think Dr. Johnson can answer that.

Dr. Johnson. We have had further flight extensions, which takes care of the immediate need very well. That class of aircraft is in pretty good shape if further flight extensions are approved.

Mr. Goldwater. Do you have sufficient helicopters?

Dr. Johnson. At the present, yes, but that is a problem that will come up in the future. It will be not many years before we will be thinking of helicopters.

Dr. Atkinson. The Navy's changeover to a new type of helicopter will require us to purchase them, too.

Mr. Goldwater. Dr. Atkinson, I notice that you have something like 1,200 personnel in the National Science Foundation. Is that correct?

Dr. Atkinson. Between 1,200 and 1,300.

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Mr. GOLDWATER. Why do you need so many people to administer that agency? You have no in-house activity. All you're doing is administering money.

Dr. ATKINSON. That's true, but we always view NSF's overhead costs as remarkably low for any Federal agency. This year, for example, we are proposing an increase of only one-half of 1 percent in funds for program development and management. We are asking an increase in personnel also, but I think NSF's personnel total is tight; we really have been shorthanded.

Mr. GOLDWATER. Does it really take that many people to process $1 billion, a little bit over $1 billion?

Dr. ATKINSON. We think it does. The key aspect of the process is peer review. Each proposal that we receive is reviewed by 4 to 12 scientists outside the Foundation. Those reviews are free of charge. And then those reviews must be pulled together, evaluated, and compared against others before a decision, is reached.

[Additional information for the record follows:]

NSF STAFFING AND WORKLOAD

By comparison with other agencies, NSF handles many times the number of projects than the size of its budget would indicate. The Foundation receives over 26,000 proposals each year and selects some 13,000 for funding, based on review by expert scientists. Over 80,000 scientific reviews related to these proposals are solicited and analyzed. Each case must be decided fairly and documented well. Almost 35,000 awards active at over 2,000 academic institutions and other organizations are monitored by NSF program staff.

The Foundation operates basic research programs in all scientific disciplines, selected areas of long-term applied research, and efforts to improve science education. The Foundation also participates in cooperative research programs having international implications; conducts surveys; develops reports on scientific manpower resources; and analyzes scientific policy issues. The agency also manages certain large scientific research projects such as the U.S. Antarctic Program and the Deep Sea Drilling Project, and oversees projects such as the construction of the Very Large Array (the world's largest radio astronomy instruments). Six national research centers are also managed by NSF. They are targeted for research in astronomy and the atmospheric sciences and are operated under contract by university groups.

The fiscal year 1981 budget is based on a program structure of 11 major activities in scientific research, science policy and science education. These activities (e.g., Mathematical and Physical Sciences, Engineering and Applied Sciences, etc.) are further subdivided into some 32 discrete areas corresponding to groupings of science disciplines (chemistry, physics, etc.) which are in turn subdivided into approximately 160 individual scientific program elements. Each program element requires expert scientific staff knowledgeable in their respective program areas, as well as clerical and administrative support.

Activity has dramatically increased over the past several years independently of the change in the size of the Foundation's budgetary resources, i.e., the number of proposals received is not directly dependent on the availability of funds. All proposals must be processed and reviewed. A determination whether or not to fund must be made, and the institution and the research investigator informed. Each step of this process must be fully documented and reviewed by action review boards. Moreover, we strive to give each applicant the best possible feedback and to operate in an open and evenhanded manner. Since fiscal year 1974 there has been a 20.4 percent increase in the total number of proposals submitted and which require processing and review (from 21,537 to 25,928), while during the same period staffing increased only 5.8 percent (from 1,190 to 1,260).

While some of the workload pressure has been offset through use of automation, simplified procedures, and reallocation of positions, a detailed staffing requirements study recently conducted by the Foundation indicates that serious staffing shortages still exist in some program areas. The study indicates that far from being over-staffed, the Foundation, in order to fully meet its statutory requirements and to ensure that the most meritorious proposals are funded, should ameliorate the existing workload to staff ratio by adding a number of program officers and associated clerical and support employees.

Mr. Goldwater. I assume this committee will get into that question in more detail. It just seems to me like an awful lot of people for a relatively small amount of money, but maybe I don't understand the intricacies of what it is that you do.

Mr. Macy. I think the Federal Government in their managing of disasters should look to the States for a lot of the preparatory work to responding to a disaster.

Do you provide monies for States to put together a central management organization which would include such things as a statewide inventory of available resources: bulldozers, helicopters, ambulances, emergency pumps, generators, et cetera?

Mr. Macy. We don't have it for that specific purpose, but there are a number of grant programs to the States that have been a part of the Civil Defense activity for some time. The provision is for matching funds to cover personnel that are engaged at the State and local level in that kind of preparedness activity.

There has also been available to States and municipalities up until recently a program whereby they could acquire excess equipment from the Department of Defense.

We are in the process of reviewing with the States and the cities at the present time the needs that may exist for that kind of equipment to support emergency activities generally as we move to the concept of comprehensive emergency management, rather than putting it in separate packages for different kinds of emergencies.

Mr. Goldwater. In one of our earthquakes, a dam cracked, with 90,000 people in the area. We tried to find an electric pump to pump the reservoir out and it was several days before they got one in, and then found out that there was a pump sitting not more than 1 mile away that they could have used.

The State of California has explored putting together a central management concept, with an inventory of these kinds of equipment, which would be computerized, I suspect, and available throughout the State at various locations, and there was some applications discussions with your predecessor agency, but I don't think anything ever came of it. It seems to me that would be an essential bit of knowledge to have, to be able to respond with the necessary kind of equipment and services in any kind of an emergency, small or large.

I would like to know from you more about your ideas on that, and whether in fact you have moneys available in applications today for that kind of thing.

Mr. Macy. I will provide that information.

[The information to be provided is as follows:]

While there are no specific requirements—and no specific funds—for Statewide inventories of emergency resources, FEMA does provide some funding that can be and has been used for that purpose, if the State chooses to do so.

A few did so with a portion of their Disaster Preparedness Development Grants from FDAA under the Disaster Relief Act of 1974. (These grants provided up to $250,000 per State for planning and other purposes. They have been completed and the funds exhausted.) For example, Connecticut produced an Emergency Resources Directory and Iowa developed a computerized Resources Management System.

Such use of the development grant was not encouraged simply because most States had higher-priority needs for the grant funds, particularly for developing basic disaster assistance plans and procedures for using Federal aid in disasters. If funds were sufficient for such basis efforts and for resource inventories, then the latter projects were approved. Also, resource inventories, if too detailed, soon become obsolescent and are expensive to maintain. We consider it more effective to know *where* and *how* needed resources may be obtained than to know precisely what is available.

At present, a $25,000 maximum Disaster Preparedness Improvement Grant is available to each State once a year on a 50–50 matching basis. This too can be used for resource inventorying, although its primary purpose, as stated in the Act, is to improve, maintain and update State disaster assistance plans. Realistically, the small amount is more conducive to upkeep of existing plans and capabilities than to new projects. Some States, however, could make effective use of that grant for resource inventorying.

Under the Civil Defense Act of 1950, Public Law 81–920, we provide financial assistance on a 50–50 matching funds basis to State and local governments for civil defense personnel and administrative expenses. In fiscal year 1979, the personnel and administrative expenses of 1,264 State employees were matched under this program. While the primary purpose of this program is to develop an attack preparedness capability, they can, as part of their preparedness function assist in developing a Statewide inventory of available resources. This is in accord with the 1976 amendment to Public Law 81–920 which states: The Congress recognizes that the organizational structure established jointly by the Federal Government and the several States and their political subdivisions for civil defense purposes can be effectively utilized, without adversely affecting the basic civil defense objectives of this Act, to provide relief and assistance to people in areas of the United States struck by disasters other than disasters caused by enemy attack

Mr. GOLDWATER. I have further questions, but I'll yield to the other members.

Mr. BROWN. You're the last member here, Mr. Goldwater, if you wish to continue.

Mr. GOLDWATER. I have a couple more questions.

Dr. Atkinson, one of your programs involves small businesses, and increasing the research opportunities of small business. Can you explain in a little more detail what that's all about?

Dr. ATKINSON. We have been running the program experimentally for about 2 years. Small businesses apply to NSF for support of research that they consider innovative and potentially productive. In the first phase of the program, we provide $25,000 for the small businesses to develop their plans for research projects. These grants are highly competitive; about 12 percent of the applicants receive funding in the first phase.

If the outcome of the first phase is promising, a larger grant can be made to support research activities in the second phase. We make the larger grant only in a competitive process, and the company must obtain a commitment of venture capital for product development.

We find that many small companies obtain access to venture capital through this program because the National Science Foundation supports the high risk research that establishes the feasibility of the innovative idea.

You might say, "Well, it can't help but be exciting if you are funding only 12 percent of the proposals." We expect the program to remain competitive, and it is giving small companies with innovative ideas an opportunity to pursue them with Federal funds.

Mr. GOLDWATER. For instance, in the last year how many applications were made?

Dr. ATKINSON. I'll refer to Dr. Sanderson here. He's the assistant director responsible for the directorate that manages this program.

Dr. SANDERSON. The last solicitation which we ran was in 1979. We received 408 proposals and made 54 awards for the first phase—to take a look at the idea and to do the fundamental research necessary to prove a reasonable approach.

We received 329 proposals in the 1977 solicitation and we made 42 awards. Of those awards, 21 continued into the second phase of research that Dr. Atkinson has described to you.

A third solicitation closed about a week and a half ago. We received approximately 500 proposals in that solicitation. We haven't had a chance yet to look at the quality of those proposals.

Mr. GOLDWATER. How do you make the solicitations known to the general public?

Dr. SANDERSON. The solicitation is made known through a variety of mechanisms. First, we publish it in the standard trade journals, such as the Commerce Business Daily. We also obtain a mailing list of high technology firms from a number of organizations such as the Small Business Administration and the National Association of Manufacturers. In all, we mail several thousand direct announcements of the solicitation, in addition to advertising its availability in a number of the trade journals.

The Foundation also runs each year two Small Business Conferences at different locations within the United States. There are two scheduled this spring; one at Los Angeles, March 10 and 11, the other at Atlanta, March 25 and 26. At those conferences NSF and 14 other Federal agencies send representatives to meet for a couple of days with small businessmen in the area who attend the conference. We sit down and have a 1-on-1 discussion of opportunities to participate in Federal R. & D. programs.

Mr. GOLDWATER. What's the total dollars in that program?

Dr. ATKINSON. In the fiscal year 1981 budget it will be about $13 million.

Mr. GOLDWATER. This would not impact upon the so-called inventors program, or somebody who just had an idea? This would be ongoing with small businesses that are economically viable?

Dr. ATKINSON. The small businesses involved range from one-person firms that are formed a few days before the award is made to fairly substantial companies. The criterion that they must meet is the SBA definition of a small business.

Dr. SANDERSON. Four companies that received awards were companies of one person or one or two persons working in their homes. NSF requires the small business to be the legitimate primary source of income for the principal investigator involved. It can't be a moonlight operation while the investigator is working for some other organization as his or her primary source of income. It must be a serious business to which the person is committed.

Mr. GOLDWATER. Dr. Ambler, when Mr. Glickman was talking to you about your inventors program, I believe he asked you what you need to do a better job, and you replied that everything was fine, you're doing a good job, you're satisfied with your dollar level, you have sufficient personnel aboard to do the administrative work, and everything is fine. Is that correct?

Dr. **Ambler**. Yes. That's what I said, yes, sir.

Mr. **Brown**. Would the gentleman allow me to make a point here, that Dr. Ambler indicated that this program is financed through the Department of Energy. So the money comes from the Department of Energy to the Bureau in order to do the work at whatever level of volume and quality that they need to do it. So we need to inquire probably of the Department of Energy whether they think this is a problem.

Mr. **Goldwater**. I think that's probably true, but Dr. Ambler administers the program, and he has under him the responsibility for making the evaluations. You also have the personnel that you're ressponsible for.

You get your money from the Department of Energy is what you're saying. Is that an endless supply of money? Should you need more money could you go back to the Department of Energy, or how does that work?

Dr. **Ambler**. If we felt that the program was not being funded adequately we could certainly approach the Department of Energy and ask for more. But I maintain that we are doing a good job in that program and that the resources and staff we have on it are adequate at the present time.

Dr. **Atkinson**. Mr. Goldwater, may I say that the NSF has set up what we refer to as innovation centers at several universities. An example is the center at the University of Oregon which screens a large number of inventions, provides inventors with feedback on the significance of inventions, and advises whether there is a commercial market. In the past year, the center processed more than 4,000 such applications.

Mr. **Goldwater**. I happen to feel that's a pretty critical program. There's an awful lot of folks out there who have ideas and they don't know where to go. That's why I was sort of curious about this small business program that you have because I think it has direct or indirect impact on the availability of an outlet for ideas. Oftentimes a small business or an individual who has an idea is confronted with large businesses that will not provide protection for that individual idea, and the only other place they seem to be able to turn to is the government.

If the committee pushes for some kind of a program which wound up as the inventors program and, I suspect, the small business program in NSF, I think our interest is in making sure that that program is receptive to the needs of the American people, and an outlet where these ideas can be evaluated, and also that there's enough resources to do the job, and if there's not, then this is the time to let us know.

Mr. Chairman, I have one other area I wanted to inquire into.

The National Science Foundation evidently is doing most of the earthquake research. Is that fairly accurate? I know that you talked about some basic work in this area, and in your budget you have $1.2 million, and then you have about $20 million in other earthquake research activities.

Dr. **Atkinson**. The program is coordinated with the Geological Survey.

Mr. **Goldwater** [to Mr. Brown]. That's the program that we put together in your subcommittee?

Mr. **Brown**. Correct.

Mr. **Goldwater**. That doesn't seem like a great deal of money in relation to the damage that's done by earthquakes.

Are you satisfied with that budget level? Did you request more from OMB?

Dr. **Atkinson**. Mr. Goldwater, our ZBB packages and documents are available to this committee.

Jack, do you want to speak to that?

Dr. **Sanderson**. Yes, sir. In response to your question about requesting more, it depends on the ZBB level you want to include.

Certainly, we identified additional program opportunities in this area. However, I think it is a constrained budget, Mr. Goldwater. The President committed himself to zero growth in the civilian controllable portion of the budget because of budgetary pressure from defense and the need to control inflation. Within that constraint there has been a sizable growth in the Engineering and Applied Science Directorate, and a moderate growth in the earthquake program.

Certainly, there are areas that we are beginning to build slowly. The area of societal response received some special emphasis, first with a modest reprograming in fiscal year 1980, and then with a substantial fraction of the earthquake budget growth in the fiscal year 1981 budget.

Mr. **Goldwater**. How much did you request for this particular program initially?

Dr. **Sanderson**. Mr. Goldwater, I'd like to supply you that information for the record, if I could. I do not have the ZBB breakdown at the various levels here.

Mr. **Goldwater**. All right. Thank you. That will be fine.

[The information to be provided is as follows:]

In the fiscal year 1981 Zero-Base Budget submitted to the OMB last September, NSF requested $20.6 million for the Earthquake Hazards Mitigation program. However, under the ceiling ("mark") given by the OMB to NSF at that time, only $19.8 million was allowed. Later, after OMB reviewed the Foundation's ZBB submission, the amount provided for the program was $19.4 million, which became our budget request to the Congress.

The additional $1.2 million (i.e., the difference between the NSF request to the OMB and the NSF request to the Congress) would have provided for the expansion of research involving large-scale structural testing facilities, to include studies on building components, various types of connections, and secondary building elements. New initiatives in the analysis of light-frame structures to improve the codes and standards of construction used to design and build these units, as well as methods to evaluate the hazard potential of existing buildings would have been introduced.

Mr. **Goldwater**. Dr. Atkinson, in your brochure here that you've supplied, in the various areas of science education you have $4 million for college science teaching, and "provides for subject matter revitalization of college science teaching."

What are you doing there?

Dr. **Atkinson**. Can you tell me the page?

Mr. **Goldwater**. On page 22, at the bottom.

Dr. **Atkinson**. Which one is it?

Mr. **Goldwater**. The one at the bottom, college science teaching, $4 million, "provides for subject matter revitalization of college science teaching." You imply that the quality of teaching of science courses has been on the decline, and this is an effort here to revitalize it.

Dr. Atkinson. Yes. We do run workshops for science teachers; occasionally, we develop special materials to supplement instruction in this area. Unfortunately, NSF's assistant director for science education is not here at the moment.

Mr. Goldwater. Maybe you could send up a detailed explanation of exactly what this has been doing. The thing that struck me about that effort is that it seems to me that there is a lot of publishing houses and publishers that are always trying to sell textbooks, and it would seem to me, obviously, that they would always be improving the material that's contained in the textbooks.

The question I would raise, if that's the fact, are the publishers or the authors of these textbooks on the wrong track or are they not providing current information in their textbooks that are being purchased by students, or is there something else that I'm not reading into this?

Dr. Atkinson. I do think that there is a need for research on instructional materials at the college level. I have a major textbook, and I have been in the textbook publishing business most of my life. I believe that we do need some research funds for the development of unique curriculum materials at the college level. I don't think that one should depend on the marketplace to do some of the background research for such materials; part of the work should be so oriented toward the background research. Another part of it should be oriented toward college teacher training programs in the summer months at special colloquia where new topics, new ideas, and new techniques could be introduced.

College Science Faculty Improvement

There is a growing concern in the Nation over the quality and currentness of the teaching of science in 2-year and 4-year colleges. The problem is recognized by leaders of professional organizations of scientists and educators, leaders in academic science and others who have knowledge of the need for science faculty renewal.

This need for faculty renewal results from a combination of factors both internal to institutions of higher education and outside them. Budget cutbacks in colleges have restricted already tight sabbatical leave and professional travel opportunities, the traditional method of college faculty subject-matter renewal. Increased percentages of tenured faculty, the pending extension of the retirement age and reductions in the number of faculty due to enrollment changes will have a devastating effect on the infusion of new talent into science departments. These factors combine to produce an aging and hence more expensive faculty over the coming decade. Coupled with the erosive effects of inflation, these factors will significantly reduce opportunities within colleges to address the subject-matter needs of science faculty. All this while science continues to advance at an increasingly rapid rate.

The burden on college science faculty, nonetheless, continues. Future leaders in business and government must be well trained in science in an increasingly techological society as must the next generation of scientists and engineers. Because of this the Foundation is proposing to increase the number of opportunities for college science faculty to participate in programs of short courses, institutes and conferences for subject-matter revitalization. These activities, typically held during the summer months, allow teachers of undergraduate students of science in 2-year and 4-year colleges to attend lectures and colloquia specially designed to quickly up-date their subject-matter backgrounds. The latest results of scientific research, new topics, and new instructional techniques are discussed. These sessions significantly reduce the lag-time experienced between the discovery of the new knowledge or the development of the new idea or technique and its publication in textbooks. Thus the faculty who participate in these colloquia return to their campuses ready to immediately upgrade their courses and bring the most up-to-date instruction in science to their students.

Dr. **Pimentel.** I'm the Deputy Director of NSF. May I call your attention to the last sentence on page 22: "* * * the updating of the subject-matter competence of college science faculty." You see, the emphasis in fiscal year 1981 is more on the maintenance of teachers' competence as they get further away from their university training. The nature of activities in our program—faculty short courses, science faculty fellowships, college faculty conferences—is much more directed toward renewal of teachers who have served for many years. The emphasis is much more on teacher competence than on development of materials that would compete with textbooks.

Mr. **Goldwater.** Why wouldn't that function be transferred over to the new Department of Education?

Dr. **Atkinson.** The question debated by the Congress, and the Congress came to the view that both agencies should have a role in the preparation of teachers and in the science education program.

I think it is important that science education have close ties to the scientific community, and the National Science Foundation provides those ties. In turn, the Department of Education has its own role, and we take part in joint efforts with the Department of Education. There are several joint programs where we fund proposals on a 50-50 basis, and there is close coordination between the two agencies.

Mr. **Goldwater.** The one just above that, public understanding of science, $5 million, that sounds to me like a public relations program.

Dr. **Atkinson.** No, it is not. That funding supports the "3-2-1 Contact" program just begun on public television. Have you seen it, Mr. Goldwater, the "3-2-1 Contact" program? It is a program like Sesame Street, but it is designed for junior high school level students. Its purpose is to insure that students of junior high age maintain an interest in science by providing scientific concepts in an attractive and interesting way. If you get a chance to watch "3-2-1 Contact," you will see that NSF provided, along with Exxon and the Department of Education, about a fourth of the funds to help develop the program.

Mr. **Goldwater.** Is that a television program?

Dr. **Atkinson.** Yes, it is. It is like the Sesame Street program, but it is for an older age group, the junior high school population, because many students do not continue to take science courses beyond junior high. Consequently, those students are almost isolated from any further exposure to science in senior high school and college. We need to maintain student interest in science in junior high, yet the teaching of science in the junior high school is particularly weak. I think most people will tell you so. This program is designed to encourage interest in science.

Mr. **Goldwater.** So it's a television program?

Dr. **Atkinson.** Yes.

Mr. **Goldwater.** And that's basically where the funds are going?

Dr. **Atkinson.** That is one of the subjects.

Mr. **Goldwater.** Was that a competitive contract?

Dr. **Atkinson.** Yes, it was. The Children's Television Workshop is the group responsible. The effort goes back about 5 years, and the record is available.

Mr. **Goldwater.** Let me ask you somewhat of a theoretical question. Your concern here is for the quality of teaching. Your concern is to stimulate interest of young people in science, and you have an interest in learning why women or minorities are not attracted.

Has it always been that young people have always been disinterested or turned off by science, or is this sort of a cyclical thing? That's one question.

Two: How much of this is directly related to the decline in Federal dollars going into, say, defense or the space program, where we've seen over the years levels of funding on the increase, and then all of a sudden it just simply dropped?

I recall in 1969 and 1970 we had engineers and scientists driving taxicabs, running laundrys, because the Federal funds dropped. There wasn't any kind of trickle off. It was just an immediate cut. Every time we cancel a major defense contract, like the B–1 bomber, or a ship, or anything of that type, you see an excessive number of adult engineers running around the streets. Today we're seeing an attack on nuclear power and a threat to that industry infrastructure, and because of these phenomena we see the impact trickle back through the pipeline to the students who are looking at their careers for life and seeing that that's no longer attractive and the demand's not there, and their attention is focused some place else. This lack of interest, and perhaps the quality of teaching, is one consequence of an economic squeeze on science and upon the industries themselves.

Dr. Atkinson. Your comment about the drop in employment of engineers, and in aerospace industry activities interests me. We are beginning to recover, in the sense that the schools of engineering are beginning to turn out numbers of critically needed engineers. Frankly, the need for engineers is so great that when engineering students receive bachelor degrees they are going directly into industry at high salaries, and we are not able to draw enough students into graduate engineering training to maintain the flow of Ph. D.'s needed in engineering and computer science.

I was distressed recently to learn how large a percent of the Ph. D. students in engineering in U.S. universities are non-U.S. students. Nearly 50 percent of the graduate students working for Ph. D.'s in engineering are non-U.S. citizens. We are facing a serious problem there.

Now, I think we hear too much about the taxi driver, unemployed scientist. In a few fields of science, there has been overproduction. In some fields, high energy physics and astronomy, the job market is very tough. But in other areas we are not producing enough people. It is an important issue to face, and there is no simple answer.

Mr. Goldwater. It seems to me, and I think commonsense would tell you, that when there is not a market for engineers, for whatever cause, or where you see a cutback in a major program by an agency of the Federal Government, students who are looking for where to go don't see the demand there and may choose another field. As a result after we get over that dip, the demand starts building back up, but we don't have the resources following. This concerns me greatly in nuclear physics, in the whole nuclear power industry. There obviously is a legitimate need to examine nuclear policy, and no one quarrels with that. But when we see the attack on the nuclear industry and a curbing of Federal dollars, the lack of licensing, not building nuclear powerplants, the lack of continuity within the whole nuclear industry, all of a sudden you see a backup of qualified people, an excess supply of personnel, and no great demand, as a result. I can see later on, in another 5 or 10 years from now, we may very well need that resource after we've determined the level of nuclear effort, we'll support, and gotten it back on the track. We're then going to need that personnel resource, and I don't think we're going to have it. The kids today are going to look at this, and say, "I'm not going to go into nuclear physics. The job security is not there."

Dr. ATKINSON. Mr. Goldwater, those are interesting comments. My opening remarks were confident on the state of American science, and I feel that way. If there is one thing I worry about, it is the fact that we are not drawing enough very talented people into science. In the Sputnik period, there was a tremendous interest, but that interest has cooled. I am frankly disturbed when I see the percent of premed, prelaw, prebusiness students in the universities and the lack of enthusiasm for doctoral work in the sciences. We need those people; it is a real cause for concern.

Mr. GOLDWATER. It seems to me that it's a problem that needs to be better understood, and I'm not sure there's a real solution to it. But somehow or other these peaks and valleys have got to be evened out so that we don't have this drying up of resources. Somehow, maybe at the Presidential level, or the President's Science Adviser, someone can monitor this and make projections over the long run. If the policy is to kill the B-1 bomber or to cut back on nuclear dollars, then we have to understand what the resource implications are over the long pull and not just today.

Dr. ATKINSON. Mr. Goldwater, you are discussing a responsibility of the National Science Foundation. We are responsible for making such projections, and we are making them. I look at, for example, the training of grade school and high school teachers. We knew what the population figures were. We knew what the numbers were going to be 20 years ago and during the past 10 years. Yet we were expanding our schools of education, expanding the numbers of teachers; one had only to look at the simplest information to know that we were on the wrong track. These issues in science are more subtle, but I think we should worry about them.

Mr. BROWN. Are you through, Mr. Goldwater?

Mr. GOLDWATER. Yes.

Mr. BROWN. Mr. Goldwater has brought up a number of very important questions, and I'm going to ask the staff to follow up and see that we get the additional responses in writing, and I would like to ask you gentlemen if you would cooperate in completing the record by responding to questions that other members might have or members of the committee staff, and, because of the time schedule, we would like to have responses that will fit into our congressional schedule if it's possible to do so.

I recognize that we have kept you for an unduly long time this morning, and I want to express my personal appreciation, and I'm sure that Chairman Fuqua appreciates it.

This is, of course, a prelude to a more detailed examination in subcommittee of your various programs, which will give us an additional opportunity to explore some of these areas.

We're very appreciative of your kindness.

With that, the committee will be adjourned.

[Whereupon, the committee recessed at 1:05 p.m.]

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